THIRD REPORT

WELLCOME RESEARCH LABORATORIES

AT THE

GORDON MEMORIAL COLLEGE

KHARTOUM

ANDREW BALFOUR, M.D.
DIRECTOR

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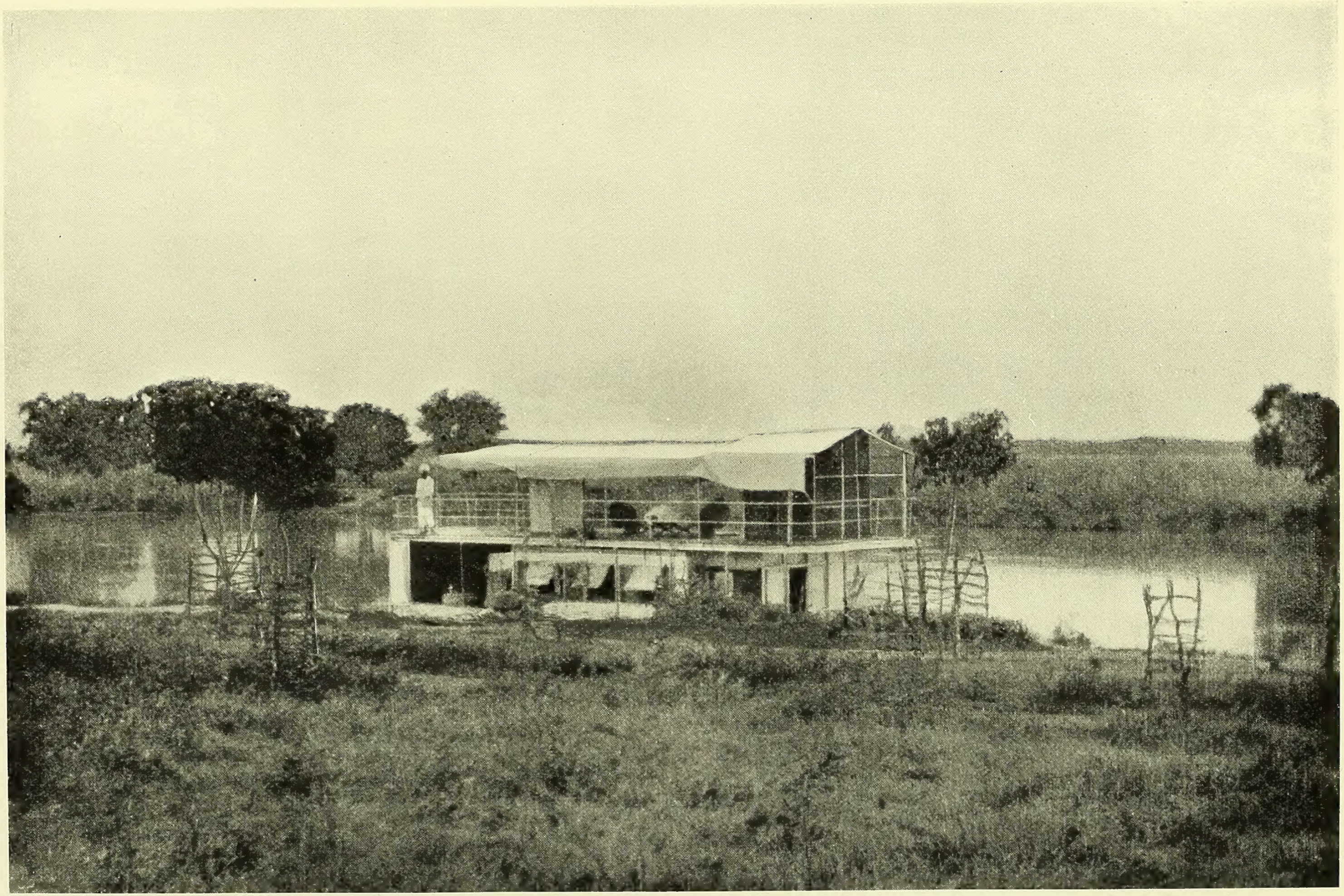

C. M. Wenyon

Fig. 1.—Floating Laboratory at Wau on the Jur River
(Auxiliary to the Wellcome Research Laboratories, Khartoum)

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ANDREW BALFOUR, M.D., B.Sc., F.R.C.P. Edin., D.P.H. Camb.
DIRECTOR

Fellow of the Royal Institute of Public Health, the Society of Tropical Medicine and Hygiene, and the Society for the Destruction of Vermin; Member of the Incorporated Society of Medical Officers of Health, and the Association of Economic Biologists; Corresponding Member Société de Pathologie Exotique; Medical Officer of Health, Khartoum; etc.

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THE GORDON MEMORIAL COLLEGE AT KHARTOUM

STAFF

OF THE

WELLCOME RESEARCH LABORATORIES, 1908

Director	Andrew Balfour, M.D., etc.
Chemist	William Beam, F.I.C., etc.
Economic Entomologist	Harold H. King.
Travelling Pathologist and Protozoologist for 1907-1908	C. M. Wenyon, M.B., B.Sc., etc.
Pathologist and Assistant Bacteriologist (*from April,* 1908)	R. G. Archibald, M.B., R.A.M.C., attached E.A.
Assistant Chemist	J. A. Goodson, F.I.C.
Laboratory Attendant	H. R. Friedrichs, up to September, 1908. E. Inglis, from January, 1909.
Clerk	J. J. A. Vitalé, B.A.
Junior Clerk	Ibrahim Effendi Hafiz.

ACKNOWLEDGMENTS

The following have kindly contributed Papers to this Report:—

R. G. Anderson, M.R.C.S., L.R.C.P., Egyptian Medical Service.
L. Bousfield, M.A., M.D., Egyptian Medical Service.
S. L. Cummins, M.B., B.Ch., Egyptian Medical Service.
E. S. Edie, M.A., B.Sc., Carnegie Research Fellow in Chemistry, 1907-1908.
R. T. Leiper, M.B., F.Z.S., Helminthologist, London School of Tropical Medicine.
W. H. McLean, A.G.T.C., Gordon College, Khartoum.
Sir Rudolph Baron von Slatin Pasha, K.C.M.G., C.B., C.V.O., Inspector-General, Sudan Government.
F. V. Theobald, M.A., Vice-Principal and Zoologist to the S.E. Agricultural College, Wye.
Doctor F. Werner, The University, Vienna.
Bimb. Hassan Eff. Zeki, Sudan Medical Dept., Med. Off., Gordon College, Khartoum.

Dr. D. W. Waterston and Mr. D. J. Vallance have compiled and contributed Papers based on the notes and material collected by the late A. MacTier Pirrie, M.B., B.Sc., Carnegie Research Fellow in Anthropology for 1906–1907.

Capt. Howard Ensor, M.B., D.S.O., E.M.S., has furnished information regarding the question of Sleeping Sickness in the Bahr-El-Ghazal Province.

W. FEAM

Exterior Wellcome Research Laboratories, Khartoum

Showing damage caused by the fire of May 11th, 1908

The destruction of equipment and materials was practically complete, and many valuable records were lost. The Laboratories are now entirely re-fitted and re-equipped with the very latest scientific apparatus and appliances, and the work is again in full progress.

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LIST OF ILLUSTRATIONS

W Beam

Fig. 2. Gordon Memorial College, Khartoum, 1908

INTRODUCTION

IN presenting the Third Report of these Laboratories it is necessary to correct the apparently prevalent and erroneous idea that the Laboratory Reports are issued annually. This is not the case. No fixed period is allowed to elapse between the appearance of the Reports. They are issued when convenient and when sufficient material has been collected to make it worth while to undertake a task which necessitates very considerable labour on the part of all concerned and occupies much time. As a matter of fact, however, it has hitherto been found best to bring out the Reports at an interval of two years. On the present occasion I am departing in three respects from the plan followed in the two previous Reports. It will be found that in this issue papers from Sudan officials, who are not actually members of the laboratory staff, but have for the most part carried on research in these laboratories, are included. Much valuable work is being done by members of the Egyptian Army Medical and Veterinary Services, and, as it bears an intimate relation to the researches carried on in the laboratories, I felt that it would be a good thing if these outside workers could be persuaded to favour us with special articles. It is gratifying to be able to report that Captain Olver, the new Principal Veterinary Officer, and Captain Cummins, E. M. C., both of whom had in the past proved themselves good friends to the laboratories, and had done a considerable amount of work in these rooms, on being approached, at once expressed their willingness to furnish papers. These will, I venture to think, add very materially to whatever value the Report may possess.[1] Captain Bousfield co-operated with Captain Cummins in the paper on kala-azar in the Sudan.

A new departure

The question of rats and rat infection has of late years attracted much attention, especially as regards the rôle these rodents play in plague. Indeed, an international warfare is being organised against them, and they are regarded as dangerous foes to the human race. In Calcutta important work has been done in identifying and classifying the rats there present, and in other parts of India efforts have been made in the same direction. Rat destruction on a small scale has been undertaken in Khartoum, but labours under many difficulties which need not be here detailed. It is, however, important that we should know the various species which infest the town. I was acquainted only with *Mus decumanus* and *Mus alexandrinus*, and accordingly I asked Captain Flower, of Cairo, if he would care to contribute a paper on the subject. He very kindly consented to do so, and arrangements were made to furnish him with material. Unfortunately, however, he was unable to complete his paper, partly because of the difficulty in identifying the various species, and partly because sufficient material was not sent in time. It is hoped to present his paper in the next Report. Doctor Franz Werner, of Vienna, has been good enough to contribute articles on the poisonous snakes of the Sudan, and on various interesting reptiles collected by Dr. Wenyon. Doctor Werner is a well-known authority on these matters, and some years ago visited the Sudan and the laboratories, which have greatly benefited by his skilled assistance. Mr. Curtis very kindly collected much useful information as regards the "spitting-snakes" of South Africa. It is hoped to utilise this at a later date.

The rats of Khartoum

Sudan snakes and other reptiles

I would also draw attention to the historical paper by Dr. Hassan Effendi Zeki, of the Sudan Medical Department and Medical Officer of the Gordon College, who, in the troublous days preceding the reconquest of the country by British and Egyptian troops,

Historical paper

[1] Unfortunately the paper by Captain Olver was not received in time for publication.

occupied the important, if precarious, position of medical adviser to the Khalifa. Doctor Hassan Effendi Zeki naturally possesses an unrivalled knowledge of the medical and surgical practices which were in vogue amongst the Dervishes, and he has kindly given the benefit of his remarkable experience. I approached him, at the suggestion of Mr. Wellcome,[1] to whom he had previously sent a paper on the subject. The present article has been enlarged and amplified from the original, and, perhaps more than anything else could do, points to the change which has come over the Sudan since it fell under civilising influences. In this connection it is also of interest to note that our chief native laboratory attendant, who can now be trusted to make excellent blood films and attend to the sterilisation of bacteriological media, was one of the fighting Dervishes in Kordofan, while the man who keeps the museum clean, served in the ranks of the Khalifa at the battle of Omdurman. As an addendum to Dr. Zeki's paper I had intended to contribute a few notes on native Sudanese remedies, some of which are of considerable interest and not devoid of value, but I was unable to find time to do so at any length, and the fact that Bimbashia Anderson and Bousfield kindly sent in valuable papers, dealing to some extent with the question, rendered it unnecessary.

Dervish warriors as laboratory attendants

Sir R. Baron von Slatin was also good enough to collect some interesting information on this topic.

An ethnological paper

I am specially indebted to Captain Anderson for his notes on medical customs and superstitions in Kordofan. They represent very careful and accurate research upon a fascinating subject, and, I think, constitute the most important ethnological work which has yet been performed in the country.

Review of recent work in Tropical Medicine, etc.

Another new feature in the present Report will be found to consist of a brief Review[2] of the most important recent advances and discoveries in tropical and veterinary medicine, bacteriology and hygiene. I am aware that it is very difficult for medical and veterinary officers stationed in the Sudan to keep in close touch with current literature. It is difficult enough even when one is located in fairly well equipped laboratories situated in the capital of the country. It is quite impossible for those working in out-stations or travelling about. Hence it occurred to me that these officials, to many of whom the laboratories are indebted for notes and specimens, might appreciate a paper of this kind. No attempt has been made to produce a text-book, and, indeed, I fear that in several respects the *résumé* will be found deficient, for one has not time or opportunity to read very fully and thoroughly the vast mass of literature which accumulates on these subjects. Still for the past six years a certain number of leading British and Foreign journals have been regularly laid under contribution, while an attempt has been made to become acquainted with the most up-to-date text-books and treatises. The fact that H. E. the Governor-General kindly granted me a month's study-leave for special work on water bacteriology in the summer of 1907, enabled me to make good some deficiencies. The various references are given so that those who wish to go more fully into any special subject may be able to obtain the original book or paper, and it is hoped that the notes may also stimulate enquiry and indicate subjects requiring elucidation in the Sudan. As far as possible the references have been confined to sound, practical papers likely to be helpful, but the scientific aspect of certain questions has been considered for the reasons stated above.

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[1] Mr. Wellcome is organising an historical medical exhibition to be held in London shortly. Those interested in ancient and native medicine and surgery would do well to communicate with him.—A.B.

[2] This Review is issued as a Supplement to the Report and is contained in a separate volume.

The third change is the introduction of a chapter under the heading of "Sanitary Notes," which will be found to deal chiefly with sanitation as it concerns Khartoum. In my capacity as Medical Officer of Health of that city, I have been much impressed by the useful lessons to be learned from a study of the problems in connection with the carrying-out of a sanitary policy for a new town in such a country as the Sudan. At every step the laboratory work is found to aid and supplement the hygienic measures. One cannot carry on sanitary work properly, especially in the Tropics, unless one has access to chemical and bacteriological laboratories. Hence I consider that it is not out of place to direct attention to the broader aspects of water supply, milk supply, sewage collection and disposal, etc., in a laboratory report. Indeed this line has already been followed in connection with the mosquito reduction operations (*vide* First and Second Reports). Moreover, the ordinary M. O. H. reports have, according to regulation, to be very short and concise, and in these brief articles one cannot carefully enter into the important questions which present themselves at every turn. These are of special interest, not only to Khartoum, but to other of the northern Sudan towns, and have a direct bearing on tropical sanitation in all hot, dry and dusty countries. Finally, it seems to me only fitting that the early sanitary history, of a city destined possibly to become a very important centre, should be recorded in some more permanent manner than has hitherto been possible.

Sanitary Notes

Sanitary work and the Laboratories

As regards the general laboratory work one can again report very considerable progress in several directions. The chemical investigations have now become most important and extensive, and there is such a mass of routine work that Dr. Beam, even with Mr. Goodson's skilled assistance, finds it difficult to obtain leisure for exploiting new fields, though, at the same time, some of this routine work is itself of the nature of research. The appointment of Dr. Beam to a seat on the Central Economic Board was undoubtedly a step in the right direction, and both the Board and the Laboratories have benefited thereby, while assuredly the numerous chemical analyses have furnished most useful information which is beginning to bear fruit in several directions. With sanitary and medico-legal questions the chemical laboratory has also been concerned on many occasions. The winter of 1907 witnessed the arrival of Mr. E. S. Edie, the second Carnegie Research Fellow to be attached to these laboratories (*vide infra*). Mr. Edie was appointed to carry out special investigations on the chemistry and bacteriology of Sudan gum-arabic. It may be remembered that in the last report Dr. Beam contributed an important paper on this, the most valuable of Sudan products, and his researches soon showed that very little was really known concerning the composition of gum and the causes which lead to its formation. One had not much hope of obtaining a worker in a field so little exploited and so difficult, but happily Dr. McCormick, the Secretary of the Carnegie Trust, was able to indicate Mr. E. S. Edie, who had been engaged in advanced research, under Professor Moore, at the Bio-chemical Laboratory at Liverpool. Not only was Mr. Edie able and willing to occupy the post, the creation of which was due in large measure to Mr. Wellcome's generosity, but Professor Moore very kindly arranged that he should have some special instruction in the lines of his future work, and was also good enough to give us the loan of some useful apparatus. Mr. Edie arrived at the end of October, 1907, and soon adapted himself to his new surroundings.

The chemical work

Special research on gum-arabic

As will be seen from his report he has taken up two lines of research:—

1. Chemical—dealing with the analysis of gums from different sources and of gums of different qualities from the same species of tree, his object being to discover the relationship between the proportion of various constituents and the physical characters of the gum.

2. Bacteriological—endeavouring to isolate from gum-bearing branches bacteria which will produce gum when cultivated in artificial media, and working out the morphology and cultural characteristics of any bacteria isolated, in order to compare them with gum-producing bacteria already described. The influence of bacterial action on the quality of gum has also been considered, as have other factors which may be operative in gum production, such as enzyme action and oxidation.

The entomological work

A glance at the contents of this volume will show that Mr. King, our Entomologist, has had plenty to do. Indeed, although I knew that his services were urgently required, I had scarcely realised the full scope and variety of the work which awaited him. It is not too much to say that the native has come to look on Mr. King as a friend and adviser. His work has earned for him the name of the "Father of Flies," and it is interesting to see the Sudan field-workers crowding round him and listening eagerly to his explanations and instructions. The pity of it is that these latter are so rarely followed. Their fatalism and a natural indolence and improvidence often prevent the natives, unless supervised, from taking those active measures so necessary in cases of insect infestation in crops. Doubtless, however, they will some day be sufficiently educated to profit fully from Mr. King's investigations, and, in any case, the latter is doing a valuable and philanthropic work concerning which he gives full and interesting details, while the purely scientific side of economic entomology has certainly not been neglected. Mr. King's labours have also a direct bearing on Tropical Medicine, as witness his researches on mosquitoes and the bionomics of the Nile *Tabanidæ*. In this connection one has again to record valuable aid kindly rendered by Mr. Theobald and Mr. Austen, to both of whom the laboratories are deeply indebted. The former once again furnishes a special paper on Sudanese *Culicidæ*, for which he has at length been able to draw up a synoptic table that is certain to aid greatly in their identification.

Work on anthropology

The Carnegie Trust and the Laboratories

Yet another subject which has received attention is Anthropology. It may be remembered that in the Second Report mention was made of the fact that, at the suggestion of the Director of Education, the Trustees of the Carnegie Research Fund had been approached and had agreed to recognise these laboratories as a working place for their Research Fellows. One had hoped to secure the services of a chemist and bacteriologist, but, despite the kind help of Dr. McCormick, Dr. Dobbie of the Royal Scottish Museum, Dr. Lauder of the East of Scotland Agricultural College, Professor Muir of Glasgow, and others, one has to acknowledge failure. The men were simply not to be had. I had then to ask myself if there was any other branch of science which could be usefully exploited. Naturally one thought of Anthropology, for the more that is known concerning the natives of the Sudan the more enlightened and correct is the administration of their affairs likely to be, and this applies very especially to the less civilised races in the south. Thanks largely to Sir William Turner and Professor Cunningham, of Edinburgh, the laboratories were fortunate enough to secure the services of Dr. A. MacTier Pirrie, who held a special degree in Anthropology and was particularly well versed in physical work. Dr. Pirrie, though labouring under the disadvantage of not knowing the country, made what, under the circumstances, was a somewhat remarkable journey into the almost unknown Burun country which lies between the White Nile and Abyssinia. Apart from anthropological investigations on the Buruns, Dr. Pirrie was able to furnish the Government with some useful intelligence, and to prepare maps and plans of considerable value. Dr. Pirrie also carried on work in Khartoum, at Renk on the White Nile, at Melut, amongst the Nuers at Barboi, amongst

Dr. Pirrie's Expedition

Shilluks and Dinkas, and traversed a great deal of wild country. The reader, however, will look in vain for any detailed report from Dr. Pirrie's pen. It is my very sad duty to record the fact that his expedition to the Sudan proved fatal to this young and enthusiastic observer. He returned to Scotland early in July, 1907, suffering from continued fever and other symptoms pointing to infection with the parasite of Leishmaniosis (kala-azar). An illness of several months' duration ensued, during which, whenever his state of health permitted, Dr. Pirrie made efforts to work up his material and prepare a paper for the Carnegie Trust and the Laboratories' Report. At times he seemed to improve somewhat, but the fever always reasserted itself in a severe form. He became gradually weaker and died on November 16th, 1907. It was felt that an effort should be made fully to utilise his notes and observations, and Professor Cunningham, of Edinburgh, under whose direction Dr. Pirrie was to have worked out his results, kindly took charge of matters, and it is due to his help and to the valuable assistance rendered by Dr. David Waterston, of his department, and by Mr. D. J. Vallance, of the Royal Scottish Museum, that we have been enabled to publish a record of the work performed. Of its value I must leave others to judge. Naturally it has suffered greatly from the absence of Dr. Pirrie's guiding hand and brain, but it is fortunate that we are able to present some evidence of his skill in, and devotion to, the difficult work he undertook. The Governor of the Upper Nile Province assured me that Dr. Pirrie's method of managing the natives surprised and pleased him, and one can only deeply regret that so promising a career was cut short in this untimely fashion.

Death of Dr. Pirrie

Assistance in preparation of Dr. Pirrie's Report

Dr. Waterston has had a task of much difficulty, but has succeeded in working up Dr. Pirrie's statistics, and contributes a paper embodying, as far as possible, the results of his observations. Mr. Vallance deals with the archæological and ethnological aspects of the research. To both these gentlemen the laboratories are greatly indebted. Mr. S. C. Dunn has kindly permitted us to reproduce some of his interesting photographs of the Burun country; while mention must be made of the kind help rendered Dr. Pirrie by Mr. K. T. Stouvé, during his expedition.

The Floating Laboratory

Co-operation with the London School of Tropical Medicine

The Floating Laboratory became an accomplished fact in April, 1907, and started on a maiden trip up the White Nile in charge of Dr. C. M. Wenyon, Protozoologist to the London School of Tropical Medicine. We owe his appointment in part to the kind co-operation of the Committee of that School, in part to Mr. Wellcome, and in part to the Sudan Government, and we owe the Floating Laboratory partly to the latter and partly to Mr. Wellcome. Mr. Wellcome presented the excellent equipment chiefly intended for protozoological and entomological work, and the Government housed it and placed it upon a special barge. The working room is of considerable dimensions, completely mosquito proof, supplied with water from a tank on the upper deck, specially ventilated and in every way fitted for the purpose it is intended to fulfil. Mr. King, who spent some time in the laboratory on the White Nile and Sobat, informs me that "it is an ideal thing for working in up-river in the rains but would, I think, be infinitely more serviceable if it was not dependent on the post-boats for towing or had a small launch attached." As a matter of fact arrangements had been made for the laboratories to take over the steamer of the Slavery Department as soon as their new vessel was ready. Unfortunately the latter did not fulfil expectations and was not accepted, so that we were deprived, for the time being, of this useful auxiliary and had to do the best we could, assisted by the Steamers and Boats Department, which has aided us in every possible manner. Later on, however, we secured this small steamer, which, apart from other

The Laboratory steamer

considerations, will form a convenient habitation for workers in the laboratory. The latter can accommodate six workers with ease, and I fully expect will add yearly to our museum valuable and well-preserved collections illustrative of every branch of tropical pathology.

A suggestion for the teaching of Tropical Medicine

Indeed, I may perhaps be pardoned if I here state my conviction, already recorded elsewhere, that in the teaching of Tropical Medicine in Great Britain what may be called a marine floating laboratory would be of the utmost service. Every year I am inundated by appeals for material for teaching purposes from England, Scotland, Ireland, the United States and various parts of the Continent. It is noteworthy that amongst the institutions which apply are the two great English Schools of Tropical Medicine at London and Liverpool, and it is evident that even the latter school, despite its numerous and valuable research expeditions, cannot obtain all it requires for the instruction of its students; hence I believe the difficulty might be solved by the provision of a well-equipped laboratory on board a vessel of from 800 to 1000 tons burthen. Such a ship would be able to visit any portion of

A marine floating laboratory

the globe, could ascend large navigable rivers and would be the means of bringing back a store of most valuable material both for museum and teaching purposes. It would be the duty of whoever was placed in charge to conduct abroad the best students in Tropical Medicine of any year. Participation in such an expedition would be the prize of diligence and ability, and in such a laboratory both tutorial and research work could be conducted during the voyage. Doubtless a certain number of graduates would welcome the opportunity for such a course of study, as opportunities would be afforded for visiting tropical hospitals and laboratories in different countries. If properly approached I believe those in charge of such institutions would be glad to assist in every possible way, and they might be repaid by demonstrations of new technique and interesting specimens. These institutions are often in cities on or near the sea, as for example Calcutta, Bombay or Madras, Cairo, Alexandria or Leopoldville, Hong Kong, Rio de Janeiro, Manila, and so on. It is on the littorals of tropical countries that dengue, yellow fever and other important diseases occur, and in the event of epidemics, the infected places might be speedily visited and perhaps materially aided and benefited, while at all times the collection of specimens bearing on Tropical Medicine would form a most important duty. Specimens could be brought back in good condition, diseases studied on the spot and parasites, especially blood parasites, observed in a living state. It will be at once apparent that such a laboratory ship could be utilised for the study of zoology, especially economic entomology, botany, geology and hygiene, all subjects more or less intimately connected with Tropical Medicine.

The Challenger Expedition

The Challenger Expedition is still remembered. This scheme would provide for a kind of perpetual Challenger, and would, I think, challenge comparison favourably with any existing method of giving instruction in diseases of the Tropics. It seems to me that it is largely a question of money, for difficulties as regards stability at sea, which are important in connection with microscopic and other delicate work, might possibly be surmounted by the application of the principles of the gyroscope. I commend this idea to the consideration of those responsible for the teaching of Tropical Medicine to students in temperate climates.

Dr. Wenyon's report will be found full of interest. He has, I believe, had almost unrivalled opportunities, and he has known how to make the very best use of them. Indeed, it would almost seem as though the floating laboratory had a special attraction for objects associated with Tropical Medicine. On the initial trip the number of *Tabanidæ* which boarded the barge was quite phenomenal. They swarmed into the laboratory and sunned themselves upon the wire-netting of the windows. *Tabanus socius* was specially in evidence, and in a very short time we were able to prove that this fly, which may very well be the carrier of camel trypanosomiasis in Kordofan, harboured a species of *Herpetomonas.* I merely mention this fact here to show how speedily subject-matter for research presented itself. Another noticeable feature was the way in which the natives flocked to the barge. They had got the idea that it was a Floating Hospital and crowded on board eager to get medicine for their manifold ailments. As Mr. Wellcome had provided a certain number of simple drugs, with directions as to use printed in Arabic, some effort to help these unfortunates could be made, and in return they were, as a rule, only too glad to allow blood films to be taken and observations made concerning the illnesses from which they were suffering.

The Floating Laboratory on the White Nile

It may, perhaps, be thought that it would have been a wiser policy to confine the work within certain limits—to concentrate energy on one or two subjects. It was felt, however, that in a country like the Sudan it was better to obtain in the first instance a general idea of the field of work, and it is hoped at a later date to exploit more thoroughly those subjects which appear to have the more pressing claims to investigation.

As regards the bacteriological laboratory, I regret to say that my time for research has been very limited. Every year the routine examinations become more numerous. Moreover, the general administrative work is heavier than before and the creation of sundry Boards, whose meetings have to be attended, and the control of the public health work in Khartoum all militate against efforts at special investigation. The necessity for a prolonged and careful bacteriological analysis of the proposed new water supply for the town also greatly interfered with research. Hence the output is somewhat meagre, but in one instance is of considerable interest. Spirochætosis of fowls was found to exist in Khartoum and became the subject of extended research owing to the discovery of what eventually proved to be an "after phase" of the infection, but which, for a long time, presented a puzzling problem for solution. The state of the blood in dengue fever has claimed attention and a few experiments have been made with Derris root as a larvicide in mosquito work. Many blood examinations have been conducted and the enquiry into animal trypanosomiasis has been carried a little further afield. The disease which attacks camels in Kordofan has been studied, a new trypanosome has been found in cattle from the Kassala district, and the therapeutic action of a new arsenical preparation, allied to, but less toxic than, atoxyl has been the subject of investigation.

Research work

Piroplasmosis, as it occurs in the Sudan, has also received some attention.

Still, one cannot pretend that the research work has been in all cases satisfactory. Investigations have had to be left unfinished and sometimes a promising field has had to be abandoned or passed by. Moreover a great deal of valuable pathological material is wasted in Khartoum. Medical Officers as a rule have not time to conduct post mortem examinations in the minute manner demanded by the careful study of morbid histology, nor have they much opportunity of searching for the metazoan parasites which play so important a part in tropical pathology. Our knowledge of these worms as they occur in the Sudan is very limited; but fortunately, we have been favoured with a valuable paper by Dr. R. T. Leiper, who kindly undertook to examine the helminthological material brought back by Dr. Wenyon. However, as research was one of the main objects for which the laboratories were founded and as, at times, even the routine work was in danger of being neglected, I felt amply justified in applying for another official to act as Pathologist and Assistant Bacteriologist. I am glad to say that the post was created, and Colonels Bruce and Leishman, of the Royal Army Medical Corps, very kindly found a man to fill it in the person of Mr. R. G. Archibald, who was not only a past prizeman in pathology at the Royal Army

Necessity for increased help

Appointment of Assistant Bacteriologist and Pathologist

Medical College, London, but had worked for a year in Colonel Leishman's laboratory under that distinguished observer's personal supervision. Further, Mr. Archibald was just leaving for special service in Uganda, so that prior to his joining us in April, 1908, he had obtained practical experience in Sleeping Sickness and other important tropical disorders, many of which are identical with those prevailing in the Southern Sudan. He at once settled down to work and, apart from rendering most useful general assistance, was able to aid me in the compilation of the Review, and to undertake an investigation into the value of the native zeer as a water filter, besides instituting a comparison between his observations in Uganda and those of Captain Howard Ensor in the Bahr-El-Ghazal Province of the Sudan.

Staff changes

Otherwise the staff remains as before. Mr. J. J. A. Vitalé became Head Clerk, and was furnished with an assistant. These changes were rendered absolutely necessary by the great increase in office and clerical work.

The Museum

The Museum has continued to expand, and, in addition to pathological and entomological material, exhibits of "Solaro" tropical clothing, tablets for water sterilisation, etc., have been obtained and are likely to be of use to officials. One is always glad to receive specimens dealing in any way with tropical sanitation. Colonel Hunter and Mr. and Mrs. Broun presented native drugs from Kassala and Kordofan respectively, while the principal

Donors of specimens

donors on the pathological side have been Captains Anderson, Bousfield, Thomson, Ensor and Mackenzie, of the Egyptian Medical Service; Drs. Crispin and Waterfield, of the Sudan Medical Department; and Captains Olver and Williams, of the Veterinary Service. Captain P. E. Vaughan has once more sent many blood films, some of which proved of value; Captain C. Percival presented tsetse flies, together with notes upon them, and there have been other presentations from divers sources. A few words as to the inadequacy of the space

Lack of space

at our disposal. We have in all six rooms, but could do with twice that number. Fortunately the Director of Education will ere long be able to aid us to some extent in this direction, but one cannot help feeling that sooner or later the time will arrive when the laboratories must be housed in a special and separate building. There is no desire to be dissociated from the Department of Education, for the laboratories have benefited greatly by this relationship, and happily there will be no need to go far away. Mr. Currie is willing to grant us the ground necessary, provided funds are forthcoming. The type of building one would like to see is that in which so much good work has been performed at Manila in the Philippine Islands. We look forward to the day when all the various branches of Science represented in the Sudan will be gathered under one roof, and when the usefulness of the laboratories will be enhanced by the establishment of a serum department. Scientific

The outlook

veterinary work is of the utmost value and importance in such a country as this, and the laboratories should certainly be able to afford the Veterinary Officers every facility for the manufacture and storage of curative and preventive sera as well as for the study of the numerous diseases which affect Sudanese stock. Sera, for use in medical cases and vaccine lymph, might also be manufactured, for at present transport, especially in the summer, is apt to ruin lymph and serum, and in a hot country curative sera may rapidly lose their potency unless very carefully stored. Doubtless a long time must elapse before such an ideal is attained, but a first step would be the provision of new premises, which would be carefully planned to afford every facility for working; a point even more important in the Tropics than within the temperate zone.

We have been so fortunate in the past in getting what was absolutely essential that one is not without hope for the future. Thus in 1907 we again received a special and much needed grant of £E 150 for books and periodicals. It is remarkable how very little can be got for such a sum when the back numbers of important journals are concerned, but still this grant has aided us very considerably and the library is at last approaching respectable dimensions. We are again indebted to the Department of Agriculture, U.S.A., and to many British, Colonial and Foreign schools and departments for literature on the varied subjects with which we have to deal. One takes this opportunity of thanking all those who have been good enough to send us reprints of their work.

Grant to the Library

Outside aid

In one direction no real progress can be reported. The Therapeutic Garden mentioned in the First Report has not proved a success. This is partly due to the fact that it was found very difficult to obtain the required seeds for planting, and that there has been no time to devote to what looked like a promising scheme. True, we have a number of trees and shrubs which have grown at a phenomenal rate, but few of them are of interest, and I think it will be found better to utilise the garden space in other directions, as indeed has already been done to some extent. It is doubtful if the indigenous medical plants of the Sudan are of sufficient value to justify the experiment. The attempt, however, has served to secure a useful plot of land and the cost has been trifling.

The Therapeutic Garden

In the Second Report one gave a list of some of the subjects which would repay investigation. Amongst these were guinea worm infection and the therapeusis of Trypanosomiasis. So rapid is the march of progress that much which was obscure about these two diseases has been cleared up, thanks in the one instance to the work of Leiper, and in the other to the researches of Thomas and Breinl, Ehrlich and Browning, Laveran and Mesnil, Koch and many others. Mycetoma, which was also mentioned, has received attention from Brumpt, whose studies have yielded valuable information. The laboratories have been unable to deal with any of these subjects fully, but with the increase of the staff and with outside aid one may hope to extend investigations and help in work which is for the good of humanity. Attendance at the Sleeping Sickness Conference in London impressed upon one the crying need for the rapid but careful study of the diseases which tend to make parts of Africa uninhabitable alike for the black man and the white. There is much apathy amongst civilised nations, who will readily spend vast sums on all manner of objects but are too often blind and deaf to the claims of Science as a benefactor of mankind. Happily this cannot be said of the Government of the Sudan. One has received constant support from H. E. the Governor General, and it is again a pleasant duty to record the help and assistance rendered by many officials, and especially by the Head of the Department to which the laboratories belong. On the part Mr. Wellcome plays in the development of the work I need not dilate; it must be evident from a perusal of this introduction, which I would conclude by once more thanking the laboratories' staff for their loyal assistance, and at the same time expressing our indebtedness to all those who have kept our needs in mind.

The advance of Tropical Medicine

Necessity for further work

Acknowledgments

NOTE

A fire at the Laboratories

Since the above was written a heavy calamity has befallen the laboratories. From some unknown cause a disastrous fire broke out in them early on the morning of May 11th. In a couple of hours the dark room, the bacteriological room and the kitchen had been completely gutted. Not only was a large quantity of equipment destroyed, but all the trypanosomiasis strains were lost, together with records of two years' work on this subject.

Losses

Many valuable microscopical specimens, collected since the foundation of the laboratories, were consumed, as was a considerable portion of the Review, newly-written, and of which there was no duplicate. The office files for five years—books and sanitary records, being housed, for lack of space, in the bacteriological room—perished.

Unfortunately, many museum specimens, some of special interest, were in the kitchen awaiting preparation and remounting, and these were all lost. So were Mr. Edie's cultures of bacteria isolated from gum.

Timely aid

It was chiefly due to the magnificent help rendered by Colonel Chapman commanding, and the officers and men of the 1st Battalion Royal Dublin Fusiliers, and by El-Kaimakam Stockwell Bey commanding, and the officers and men of the 3rd Battalion Egyptian Army, who were assisted by the fire brigades of the Public Works Department, the Mudiria and the Gordon College, that the museum room itself and the Director's office, together with the library, were saved. The chemical and entomological rooms also escaped destruction, though considerable damage was done to the chemical equipment.

The blow was a very severe one, and has prevented the completion of several of the research papers. Nearly all the paraffin blocks prepared during the past eighteen months, and containing the embedded organs of fowls, dead of spirochætosis, were lost, and it has been impossible to collect fresh material. Work on the therapeutic treatment of trypanosomiasis had to be abandoned, and indeed in every direction we found ourselves crippled and hampered.

Re-fitting

At the same time sympathy and help were not lacking. Mr. Wellcome at once cabled his intention to refit the laboratories in the most up-to-date manner possible, and promptly despatched a large quantity of the more necessary equipment. Drs. Stephens and Breinl, of the Liverpool School, kindly replenished our trypanosomiasis strains.

Acknowledgments

Every aid was rendered us by the Director of Education and his staff, who undertook the reconstruction of the building, and from many quarters offers of assistance reached us. Thus, Mr. Hewins, the Secretary of the Central Economic Board, aided us in having the Review re-typed when it had again been written, and similar help was proffered by Mr. Huxley, of the Public Works Department. It is not possible to mention all those who were good enough to offer or render assistance, but it can safely be said that this ready sympathy and help did much to lighten the weight of a misfortune which was none the easier to bear in that it happened as the hot weather began, during which it is at any time difficult to be energetic.

Personally I would specially thank the members of the Staff for the manner in which they set to work to retrieve the damage and to help those concerned with the bacteriological work, who naturally suffered the greatest loss of time and material.

One must also express one's appreciation of the kindness shown by H.R.H. the Duke of Connaught, who graciously wired his condolences to H.E. the Governor General from Malta, as soon as he received news of the fire. At a later date the authorities at the Royal Army Medical College, London, very kindly permitted me the use of their library and reading-room.

Needless to say our grateful thanks are due to all those who strove to quench the flames and mitigate the loss. Theirs was a task of much difficulty and considerable discomfort most ably performed, and they had the satisfaction of knowing that their efforts were not in vain, for, had the museum, the library and the Director's office perished, the loss would have been irreparable. As it is, a great deal can be made good in time, and, so far as general usefulness goes, the laboratories will only be temporarily crippled. We hope to be in complete working order about the time this Report appears. Thanks to Mr. Wellcome, it was possible to undertake a certain amount of routine work by the beginning of June, the new equipment having reached us in record time. Conclusions

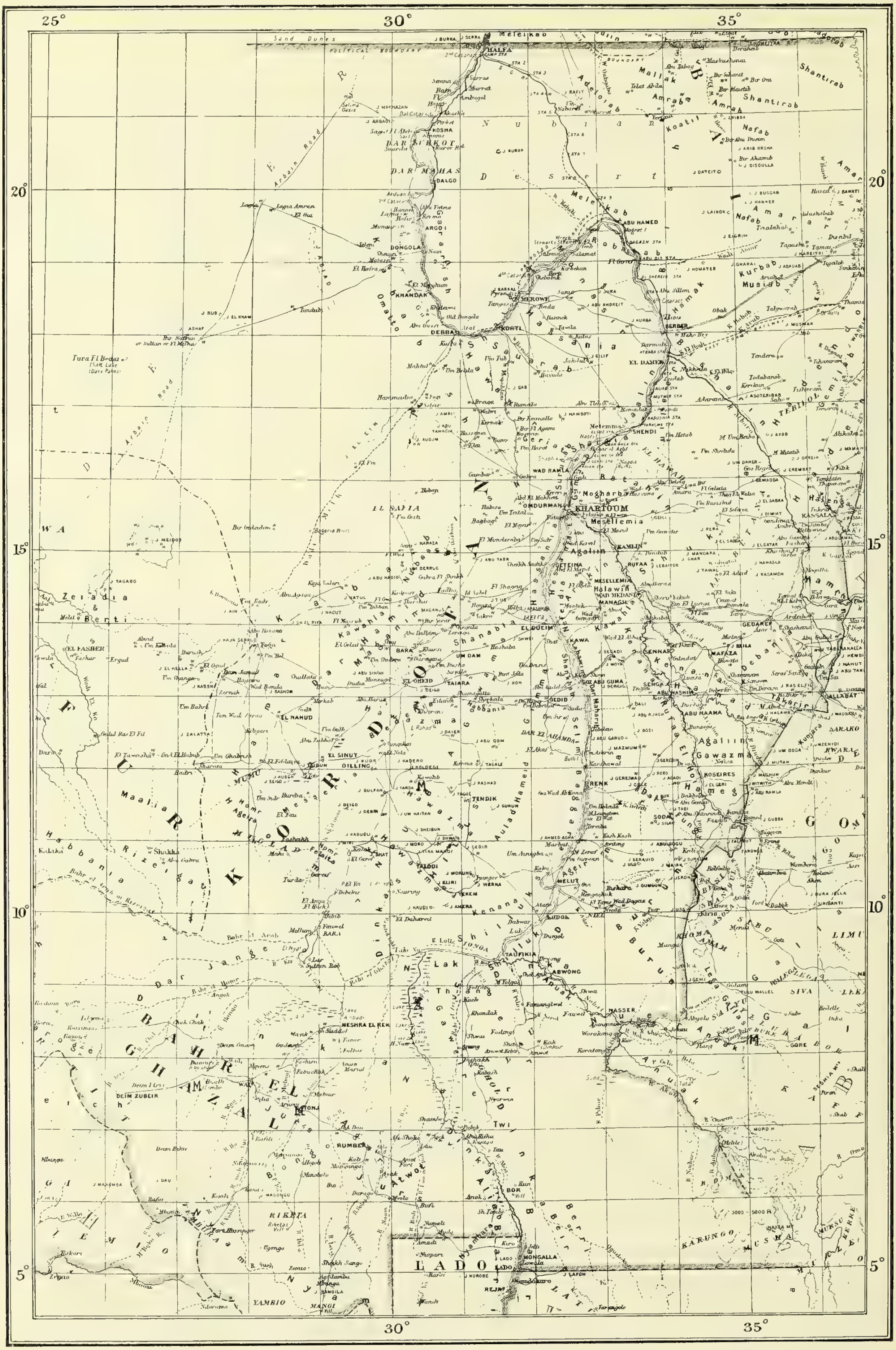

Fig. 3.—Map of Anglo-Egyptian Sudan

Trypanosomiasis in the Anglo-Egyptian Sudan

By the Director

Nearly all the records of trypanosomiasis work, and especially the experimental work on therapeutics carried out by me alone and in conjunction with Mr. Archibald, were destroyed by fire, hence this Report has had to be much curtailed.

Considering for a moment the work dealt with in the last Report, one may note that chrysoidin appeared to be quite as effectual in human trypanosomiasis given by the mouth as given hypodermically, but, as mentioned, the drug has the disadvantage of irritating the kidneys, and in any case failed to cure monkeys infected with *T. gambiense*. The case of human trypanosomiasis appeared to improve under its use, but unfortunately the patient sustained an injury to his leg, which resulted in a general septicæmia that proved fatal, despite careful surgical treatment in the Military Hospital, Khartoum. It is worth noting that at no time during his illness could trypanosomes be demonstrated in his peripheral blood.

No other cases of human trypanosomiasis, or sleeping sickness, have been available, but, thanks to the kindness of Drs. Stephens and Breinl, of the Liverpool School of Tropical Medicine, we were put in possession of a strain of *T. gambiense*. It was found that gerbils (*Gerbillus pygargus*) could readily be inoculated and they were used in the subsequent work, the object of which was to test the value of one of the new organic arsenical salts of the aromatic series, namely 'Orsudan,' which is Sodium 3-methyl-4-acetylaminophenyl-arsonate, and has the chemical formula:—

'Orsudan' as a therapeutic agent

$$\begin{array}{l} (CH_3 . CO) . NH-\langle\!=\!=\!\rangle-As \begin{cases} OH \\ =O \\ ONa \end{cases} \\ \qquad\qquad\qquad\quad\ | \\ \qquad\qquad\qquad\ CH_3 \end{array}$$

The arsonates

Arsonates have the general formula $RAsO(OH)_2$. 'Orsudan' is anhydrous and contains 25·4 per cent. of arsenic. It is soluble in three times its weight of water, yielding a neutral solution. It is considerably less toxic than atoxyl, and is the least poisonous of the three allied salts recently placed on the market. The others are 'Soamin' (Sodium para-aminophenylarsonate) and 'Kharsin' (Sodium-3-methyl-4-aminophenylarsonate). (*See* Dr. Wenyon's Report.) 'Orsudan' is only one-fifth or one-sixth as toxic as 'Soamin.' Having been successfully employed in syphilis, and as they resemble atoxyl, it was thought advisable to try them in trypanosomiasis. I selected 'Orsudan' for experimental work, and proceeded to ascertain its lethal dose for gerbils, and to employ it in the case of animals infected with *T. gambiense* (Liverpool strain) and the trypanosome of mule trypanosomiasis. At a later date, Mr. Archibald was associated with me in this work, and it is exceedingly unfortunate that all our papers were destroyed and that all the strains were lost. As a result, one cannot give the results obtained in detail while the work was cut short just when things looked somewhat promising. It was found that a healthy gerbil of average weight—about 40 grammes—could be given as a rule 1 c.c. of a 4 per cent. solution of 'Orsudan' without a lethal effect being produced.

In the case of infected animals, care was taken only to employ those which had been infected for some days, showed trypanosomes in their peripheral blood and had begun to lose weight. This is in accordance with the regulations followed by Breinl, Todd and Kinghorn.

So far as can be told, there was a difference in their reaction to the drug between gerbils inoculated with *T. gambiense*, and those inoculated with the mule trypanosome (so-called), which, as we shall see, is probably *T. pecaudi* (Laveran). The latter were found to resist the toxic effects of the drug better than the former.

Thus 1 c.c. of a 1 per cent. solution frequently proved fatal to the *gambiense* gerbil, while the *pecaudi* (?) gerbil withstood 3 c.c. with ease, as a general rule.

Action on trypanosomes

It was found that in both cases the drug freed the peripheral circulation of parasites within a few hours of its subcutaneous injection. Before vanishing, the trypanosomes assumed curious spherical shapes, and were undoubtedly destroyed, if not by the direct action of the drug, then by its influence on trypanocidal agents in the blood and tissues.

Recovery followed by relapse

In one case of *pecaudi* (?) infection a dose of 1 c.c. of a 3 per cent. solution abolished all trypanosomes from the peripheral blood within twenty-four hours, and produced a remarkable change in the animal, which had been fast going down-hill. After a short period of more acute illness it recovered, became lively and active, and continued so for ten days, its blood remaining free of parasites; then it relapsed, the parasites reappeared and multiplied in its peripheral circulation, and it died within a few days (date uncertain, as records lost). Another gerbil relapsed in a similar manner, and a further injection of 1 c.c. of a 1 per cent. solution failed to save it. In the case of a *gambiense* gerbil, the trypanosomes disappeared for nine days after treatment, at the end of which time the animal died without a relapse having occurred. The cause of death could not be ascertained. The dose was only 1 c.c. of a 1 per cent. solution, so it is unlikely that the drug was to blame.

'Orsudan' exercises no preventive action, and further work must be carried out before its precise value can be ascertained.

As regards animal trypanosomiasis in the Sudan, one has to record the discovery of trypanosomiasis in camels and of a trypanosome in cattle which differs from any hitherto found in the Sudan.

Camel Trypanosomiasis

In Kordofan

The camel disease was first investigated by Captain Olver, the Principal Veterinary Officer, and at a later date I found trypanosomes in the blood smears from sick camels sent me from El Obeid, Kordofan. More recently an infected pariah dog was sent me by Captain Anderson, S.M.O., El Obeid, and from this strain it was found possible to inoculate gerbils, jerboas and guinea pigs (*vide infra*).

Morphology

The trypanosome in question is of considerable size, and in the fresh blood displays active movements, but these are usually limited to the field of the microscope under observation. Stained specimens are found to measure from 16μ to 20·8μ in length, the majority, however, being about the latter dimension. The general form is shown in Plate I., fig. 2.

The blepharoplast is rather large and well marked, the nucleus small and compact. No granules have been noted in the cytoplasm. There is a well-marked flagellum and a well-developed undulating membrane.

More minute measurements of a trypanosome, whose total length, including free flagellum, was 20·8μ, yielded the following results:—

From posterior end to centre of blepharoplast	3·2 μ
From centre of blepharoplast to posterior end of nucleus...	4·8 ,,
Nucleus	1·6 ,,
From posterior end of nucleus to beginning of free flagellum	4·8 ,,
Free flagellum	6·4 ,,

The trypanosomes vary somewhat in breadth, but appear to average about 2μ in greatest diameter.

Comparison with allied or identical parasites

The animal reactions were tested with a view to finding out how this trypanosome was related to the camel trypanosome of the French Sudan, which causes the disease called "*Mbori*"; the trypanosome of dromedaries, *T. soudanense*, found in the regions of the Upper Niger, and causing the disease "*Le Tabaga*"; and the trypanosome to which the Algerian disease of dromedaries, "*El Debab*," is due.

Unfortunately, all the records were destroyed, and one can only say that dogs are susceptible to the disease and die from it—one noticeable feature being that, at intervals, trypanosomes cannot be found in the blood. Post mortem the spleen is found enlarged, and, so far as I can remember, there was a marked increase of pericardial fluid and some hypertrophy of the lymphatic glands, especially those in the mesentery. Guinea pigs, jerboas and gerbils are also susceptible. The last-named usually live about three months after inoculation. Of ten inoculated only one failed to become infected.

A goat was inoculated from an infected dog, but, though watched for several months and frequently examined, never exhibited trypanosomes in its blood or showed any sign of illness. It did not become emaciated or lose weight, and in this instance I think one may safely conclude that the animal did not become infected. This apparent immunity of goats is important, considering their association with camels and their great value in Kordofan.

In the absence of my notes and owing to the paucity of experiments, the strain having been lost and the work interrupted, one cannot come to a definite conclusion; but from a study of the work of Cazalbou[1] and of Laveran,[2] I am inclined to think this disease of camels is due to *T. soudanense*, provided *T. soudanense* is a distinct entity, a point by no means proved. *T. soudanense*

The trypanosome of "*Mbori*" appears to be due to a variety of *T. evansi*, and Laveran showed that a goat, recovered from "*Le Tabaga*," could be infected with the trypanosome of "*Mbori*," while a goat immune to infection by *T. evansi* could be successfully inoculated with *T. soudanense*.

"*El Debab*" the Algerian disease

It would seem that "*El Debab*," the Algerian disease described by the Sergents,[3] is in all probability identical with "*Le Tabaga*." *T. soudanense* is less virulent to mice than the trypanosome of "*Mbori*." The points which lead me to think that the Kordofan disease may be due to *T. soudanense* are the geographical distribution, though no great stress can be laid on this, the peculiar remissions seen in the blood of the dog and the post mortem appearances, more especially the pericardial effusion. I admit, however, that these are very slender grounds on which to base even a suggestion, much less an opinion, but it is hoped next winter fully to work out the morphology and animal reactions of this trypanosome, and to carry out immunisation experiments. Are results obtained by these methods sufficient to enable a differentiation to be made? Ehrlich, quoted by Browning,[4] does not think that the immunisation and subsequent inoculation advocated by Laveran constitutes a sufficient basis, but it is clear that much more work will have to be done before the precise value of this procedure is ascertained. It would seem that wherever possible it should be supplemented by cultural experiments, a means of diagnosis strongly upheld by Bruce as a result of recent work on nagana and *T. dimorphon*.

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[1] Cazalbou, L. (November 25th, 1907), "Contribution à l'étude des Trypanosomiases de l'Afrique Occidentale." *Ann. de l'Institut Pasteur*, t. XXI.

[2] Laveran, A. (May 25th, 1907), "Trypanosomes du Haut Niger." *Ibid.*

Laveran, A. (November 21st, 1904). *C. R. Acad. Sc.*

[3] Sergent, Ed. and Et. "El Debab; Trypanosomiase des Dromadaires de l'Afrique du Nord." *Ann. de l'Institut Pasteur*, t. XIX., pp. 16-48.

[4] Browning, C. H. (January, 1908), "Chemo-Therapy in Trypanosome Infections: an Experimental Study." *Journal of Pathology and Bacteriology*, Vol. XII.

As to the carrier of this camel trypanosome, we know that *Glossina morsitans* exists at Kawalib in the Kordofan Province, but the fly belt is very limited, and it is almost certain that some species of *Tabanus*, probably *T. socius*, is effective. This species has been found in the districts where the disease occurs, and the natives attribute the illness to its bite. Some species of *Hippobosca* might act as a vector, but this is unlikely, as the disease appears to be limited in range. It is worth noting that a camel trypanosomiasis exists in the northern part of the Sinai peninsula close to the Mediterranean. Here there are no tsetse flies, and Captain Cummins sent me a species of small *Tabanus* which was supposed to be the carrier of the parasite. The specimens were much damaged and could not be identified, but were sent to the British Museum. It is quite likely that this disease bears a close relation to that found in Algerian dromedaries and which is known to be transferred by a species of *Atylotus* or *Tabanus*.

Carrier of camel trypanosomiasis

Cattle Trypanosomiasis of Kassala

The new trypanosome of cattle—new, that is, to the Sudan—I found in blood smears sent me from Mendeede, Kassala Province, by Mr. R. Harold Meade, M.R.C.V.S. At my request he kindly furnished some notes upon the condition, as I was anxious to find out if the infected cattle had come from Abyssinia, in certain parts of which trypanosomiasis is known to exist.

Mr. Meade informed me that, though he could not be quite certain, he thought it unlikely that these cattle had been imported. He mentions, however, that every year Arabs are in the habit of introducing cattle from the Italian territory of Erythrea.

Biting flies of the Kassala Province

Enquiries regarding "fly" in the district elicited the information that only one *Tabanus* had been seen, and that the prevalent flies were a species of *Hippobosca*, and a fly which from its description must be a *Stomoxys*. Unfortunately, a collection of flies made by Mr. Meade was wholly destroyed by ants. I think it is probable that *Pangonia magretti* exists in this part of the Province, as it is known at Kassala, but there is nothing to prove the presence of *Glossina*. Mr. Meade also sent the following notes as regards symptoms. In this connection it must be noted that the cattle, in addition to trypanosomiasis, were suffering from a trematode infection of the lungs and heart, which probably accounted for some of the pulmonary symptoms:—

Symptoms

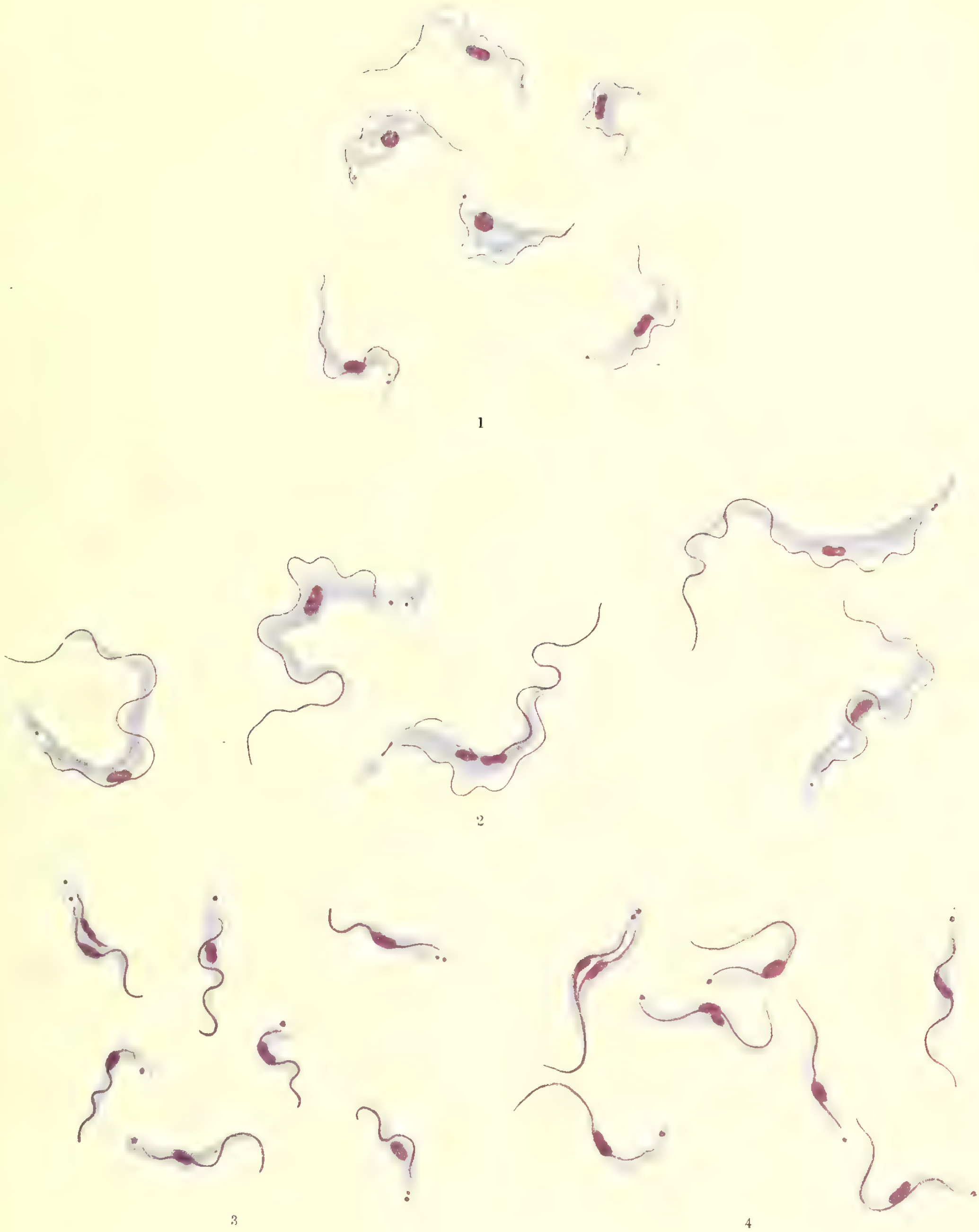
"The diseased animals have all, with the exception of two oldish cows, been under eighteen months old. On becoming ill, the cattle look thoroughly dejected and lose their appetites. The coat is rough and stands on end, the ears droop, the respirations are increased and the breathing is often distressed. There is lachrymation and blepharitis. In a few cases, blindness results after three or four days. [Possibly due to corneal opacity.—A.B.]

"A rope of mucus hangs from each nostril, and there is often a scurfy condition of the skin near the nose and mouth, together with some froth at the mouth.

"A few of the animals have diarrhœa, but the majority are constipated. The colour of the fæces is usually normal, but cases have been seen in which the fæces were coloured by blood and in a few instances sausage-like masses of coagulated blood have been passed. Some of the animals have died a few days after they were first noticed to be unwell and have been found quite fat on post mortem examination. Most have died at the end of a week or ten days, and have shown very marked symptoms of pneumonia. In none has the mouth been ulcerated, nor have the glands of the neck or mesentery seemed to me to be diseased. The post mortem examination shows the abomasum to be occasionally inflamed. In most cases it exhibits slight ulceration. The mesenteric glands are enlarged and sometimes hæmorrhagic. The gall varies in appearance from a clear fluid of a dark golden

Post mortem appearances

PLATE I



R. D. Muir

TRYPANOSOMES OF THE ANGLO-EGYPTIAN SUDAN

1. Trypanosome of mule trypanosomiasis, *T. dimorphon* or *T. pecaudi*
2. Trypanosome of camel trypanosomiasis in Kordofan
3. Trypanosome of cattle on the White Nile, *T. nanum*. This closely resembles the short form found in mules
4. Trypanosome of cattle in the Kassala Province, probably *T. cazalboui*

Leishman Stain × 1000 *diam.*

colour to a green, viscid, semi-solid liquid. Sometimes the small intestines are found inflamed, and in cases where there has been marked melæna the rectum is found full of blood."

The condition of the spleen and liver is not mentioned, but in several respects the symptoms and post mortem appearances resemble those seen in cattle affected with *T. nanum.*

Of special interest is the gastric ulceration. I examined the smears, which showed moderate trypanosome infection. The trypanosome varies in length, but is quite unlike *T. dimorphon.* Gastric ulceration

There is: 1. A short form rather resembling *T. nanum*, but measuring about 15μ in length; 2. An intermediate form about 18μ in length and showing very little free flagellum; 3. A long form about 21μ in length.

No pike-head forms were noted, such as are seen in *T. dimorphon* or *T. pecaudi* and sometimes in the trypanosome of camels.

A point which is very noticeable is that the blepharoplast is situated close to the rounded posterior end of the parasite.

The short forms resemble the typical *T. nanum* in that the undulating membrane is but slightly developed and there is hardly any free flagellum.

The breadth was found to vary between 1·5μ and 2·25μ, but I was unable to see any definite thin and broad forms, such as are readily visible in *T. dimorphon* or *T. pecaudi.* One form, 17μ in length, yielded the following measurements:— Morphology

From posterior end to posterior end of nucleus	7·5 μ
Nucleus	2 ,,
From anterior end of nucleus to beginning free flagellum ...	6 ,,
Free flagellum	1·5 ,,

In none of the forms is the free flagellum very pronounced, but in some of the long, thin forms it may reach a length of 3μ.

The general impression conveyed by a study of stained preparations of this trypanosome is that it differs from the other types found in the Sudan. It is certainly not *T. nanum*, the form hitherto found in cattle, and it is of course impossible, on morphological grounds alone, to come to any definite conclusion regarding it. Probably a specific trypanosome

The question, however, is one of very considerable importance, especially as regards trade with Erythrea and Abyssinia, and personally I have little doubt that the parasite is the same as that described by Memmo,[1] Martoglio and Adani as causing the disease *Giaān* in Erythrea.

This form of trypanosomiasis attacks cattle, sheep and goats; guinea pigs, rabbits, dogs and monkeys being refractory, as are also mice, rats and fowls.

The symptoms resemble nagana (*T. brucei*) or surra (*T. evansi*), but œdemas and skin lesions are absent. Nervous symptoms are marked towards the end of the disease.

Abyssinian sheep and goats die of the disease in 12 days. The horse is susceptible and dies in about one year, the donkey in five months. The suspected fly is a *Tabanus* or *Hippobosca.*

It would appear that the trypanosome of this disease is probably *T. cazalboui*, the cause of Souma, described in various papers by Cazalbou,[2] Laveran,[3] Bouffard,[4] Bouet,[5] and other French *T. cazalboui*

[1] Memmo, Martoglio and Adani, *Ann. d'Igiene Sper.*, 1905. Reference in Nabarro, D., "Trypanosomes and Trypanosomiasis." 1907.

[2] Cazalbou, L. *C. R. Soc. Biol.*, t. LXII, No. 21.

[3] Laveran, A. (May 25th, 1907), "Trypanosomes du Haut Niger." *Ann. de l'Institut Pasteur*, t. XXI.

[4] Bouffard, G. (December 25th, 1907), "La Souma." *Ibid.*

[5] Bouet, G. (December 12th, 1907), "Les Trypanosomiases de la Haute Côte d'Ivoire." *Ibid.*

authors, and which affects cattle, horses and mules. In the last-named it runs a more chronic course. The symptoms in cattle, as described by Cazalbou—rough staring coat, lachrymation and diarrhœa—resemble those mentioned by Meade, and the trypanosome which I have described has certain points in common with *T. cazalboui*, notably the position of the blepharoplast, the poorly developed undulating membrane with few folds and the rounded posterior end. It is true that the Sudanese trypanosome appears to vary in length, which is not a characteristic of the Souma trypanosome, but this is not a very important matter, as witness the variations met with in *T. brucei*. The films being old, and having been exposed to great heat before reaching me, did not stain very well, so possibly the appearance of forms lacking the free flagellum was due to this cause. In the absence of extended investigations, one can only say that this cattle disease is very likely the same as that found in Erythrea. As the latter is due to a trypanosome conforming to the *T. cazalboui* type, and as the symptoms of the Sudan disease resemble Souma, it seems reasonable to suggest at least that *T. cazalboui*, which certainly seems to be a distinct entity, is the trypanosome concerned. One must note, however, that a trypanosomiasis of horses (Hallen) and of cattle (Savouré) exists in Abyssinia. It is believed by these authors to be surra introduced from India. Brumpt, however, from a consideration of the commercial relations of Ogaden with the infected regions of Abyssinia, concludes that the disease is identical with the true tsetse disease of the Juba Valley and of British and German East Africa generally. This may be true nagana due to *T. brucei*, and one must not lose sight of the fact that this Kassala trypanosomiasis may also be nagana. There is nothing against such a supposition and much in its favour. Here, again, the strain must be tested and cultural methods employed.

TRYPANOSOMIASIS OF MULES { Rare form / Common form

Two types of mule disease

It will be remembered that in the Second Report allusion was made to a short trypanosome found in the blood of mules which had come from the Bahr-El-Ghazal Province.

My notes on this parasite were unfortunately lost, but some measurements made for me by Mr. Archibald show that it varies in length, from about 7·4 μ to 11·2 μ. There seems little doubt that this mule trypanosome is in reality *T. nanum*, but as Dr. Wenyon met with the disease during his journey, and was able to carry out some work upon it, which is detailed in his report, there is no need for me to say more about it, except that I was able on one occasion to inoculate a gerbil successfully from one of the dogs inoculated by Dr. Wenyon.

Up to date, therefore, the following forms of animal trypanosomiasis have been found to exist in the Sudan (*see* Plate I.):—

1. Trypanosomiasis of mules and horses, due to *T. dimorphon* or *T. pecaudi*, found on the White Nile and Sobat and in the Bahr-El-Ghazal Province. This seems also to affect cattle and camels in the Bahr-El-Ghazal Province. (*See* Dr. Wenyon's Report.) There is also a donkey trypanosomiasis, which in all probability is due to *T. dimorphon* or *T. pecaudi*.
2. Trypanosomiasis of camels, due possibly to *T. soudanense*. Found in Kordofan.
3. Trypanosomiasis of cattle due to *T. nanum*. Found chiefly on the White Nile and Sobat. (*See* notes by Dr. Wenyon, who has found a form with a free flagellum.) Trypanosomiasis of mules due to a small trypanosome which is almost certainly *T. nanum*. Found in the Bahr-El-Ghazal Province and probably on the White Nile and Sobat.
4. Trypanosomiasis of cattle due to a new trypanosome. Found in the Kassala Province. Probably either *T. cazalboui* or *T. brucei*.

PLATE II

R. D. MUIR

HERPETOMONAS PARASITES *(Crithidia pulicis)* IN HIND GUT OF FLEA *(Læmopsylla cleopatra)*

Eosin-Methylene Blue Stain × 1000 *diam.*

Finally, one must consider certain points, as regards No. 1, raised by Laveran and by Dutton, Todd and Kinghorn.[1] The trypanosome in question was described and figured in the Second Report of these laboratories, and details given regarding its animal reactions. The conclusion reached was that, of the trypanosomes then described, it seemed most to resemble *T. dimorphon*, but one preferred to name it merely the trypanosome of mule trypanosomiasis in the Anglo-Egyptian Sudan.

Recently Laveran[1] has suggested that it may be identical with *T. pecaudi*, the cause of the disease Baléri, a form of equine trypanosomiasis described by Pecaud in 1906, and which appears to have a fairly wide distribution over the north of the Ivory Coast, Upper Senegal, and in the region of the Bani in French Nigeria. One has studied the various papers of Laveran,[2] Bouffard,[3] Cazalbou,[4] Bouet,[5] Thiroux and Teppaz[6] on this form of trypanosomiasis and compared their results with those obtained in the laboratories at Khartoum. It is specially unfortunate that the records of nearly two years' further observations on the Sudan trypanosome and all the strains of this parasite were lost in the fire, for a good deal of material had been collected, and without my notes I cannot detail all that had been done. It may be said at once that cultural experiments proved negative, but I lay no stress on this point. In some instances bacterial infection was to blame, in others I find the technique was not all that could have been desired; for instance, I was not aware that it was better to defibrinate the infected blood before inseminating the blood-agar tubes. It is hoped during the coming winter to experiment in this direction, especially as more skilled assistance is now available. Lack of time greatly hindered this part of the research.

T. pecaudi

Taking first the symptoms, one finds the French observers somewhat at variance. Thus Bouffard has never seen in the horse the cutaneous symptoms, notably the dourine-like plaques described by Cazalbou. I have never seen these in infected horses or mules in the Sudan. However, it would appear that clinically it is difficult to make a diagnosis and the differentiation of *T. pecaudi* from *T. dimorphon* according to the French savants is to be based chiefly on morphology, on animal reactions and on immunisation plus inoculation experiments.

T. pecaudi contrasted with *T. dimorphon*

In both there are long and short forms of parasite. Laveran notes that the long form of *T. dimorphon* has not a free flagellum like that of *T. pecaudi*, but then again, Dutton and Todd state definitely that they have seen long forms with free flagella. Bouffard points out that the forms of *T. dimorphon* without flagella are shorter and less thick than those of *T. pecaudi*. He has never seen *T. pecaudi* agglutinate under the cover glass.

Of more importance is the persistence of this characteristic in inoculated laboratory animals. It appears to be lost in *T. dimorphon* but persists in *T. pecaudi*, and moreover the two characteristic forms of trypanosome persist, and are always to be found in the blood of animals inoculated with the parasite of Baléri. These forms cannot be separated, a point proved by Pecaud and by Laveran.

[1] Laveran, A. (February 4th, 1907), "Nouvelle Contribution à l'étude de Trypanosomiases du Haut Niger." *C. R. Acad. Sc.*, t. CXLIV.

[2] *Ibid.* (May 25th, 1907), "Trypanosomiases du Haut Niger." *Ann. de l'Institut Pasteur*, t. XXI.

[3] Bouffard, G. (December 25th, 1907), "La Souma." *Ibid.*

Bouffard, G. (January 25th, 1908), "La Baléri." *Ann. de l'Institut Pasteur*, t. XXII.

[4] Cazalbou, L. (May 15th, 1907), "Note sur la Baléri." *Revue Gén. Méd. Vét.*, t. IX.

[5] Bouet, G. (December 25th, 1907), "Les Trypanosomiases de la Haute Côte d'Ivoire." *Ann. de l'Institut Pasteur.*

[6] Thiroux, M., and Teppaz, M. (March 25th, 1907), "Les Trypanosomiases des Animaux au Sénégal." *Ibid.*

As regards animal reactions, Laveran notes that with *T. pecaudi* there is in the case of mice no disease running a slow course, and with enormous splenic enlargement, as is found with *T. dimorphon*.

He has shown that a sheep recovered from *dimorphon* infection could be inoculated with *T. pecaudi*, and, if such experiments are reliable as tests, has in a similar way proved the specificity of *T. pecaudi*, so far as the trypanosome of Mbori (var. *T. evansi*) and *T. soudanense* go. When an animal immune to Mbori is inoculated with *T. pecaudi*, *both forms* of the latter trypanosome appear in its blood.

Bouffard mentions that the marked susceptibility of guinea pigs to *T. pecaudi* helps to distinguish it from *T. dimorphon*, as the latter is not found in large numbers in the blood of inoculated guinea pigs.

Bouet, who thinks it is easy to distinguish typical *T. dimorphon* from typical *T. pecaudi*, except when the former shows forms with free flagella, regards Baléri as a more severe form of trypanosomiasis than that produced by *T. dimorphon*.

What is the common mule trypanosome?

Turning now to the Sudan trypanosome, one finds that the long and very thin form found in mules certainly tends to disappear when passed through a long series of gerbils, but, at the same time, there is no doubt that two forms—a long form with a well-marked free flagellum and a short thick form with no free flagellum—do persist. I remember that two guinea pigs inoculated from gerbils became inoculated and, I think, showed a good infection. One of them died of the disease. I do not remember ever having seen the trypanosome agglutinate under the cover glass, though I have examined hundreds of specimens. After a careful study of the French work, and speaking, perforce, to some extent from memory, I think that Laveran is correct in supposing that the mule trypanosome of the Sudan is more like *T. pecaudi* than *T. dimorphon*. One, however, asks the question, are these valid types? Is the disease not merely nagana and the parasite *T. brucei*? We know the latter assumes various forms in the blood, and when I submitted a slide of gerbil's blood, showing the mule trypanosome, to Colonel Bruce, he declared it to be exactly like *T. brucei*.

Value of cultural methods

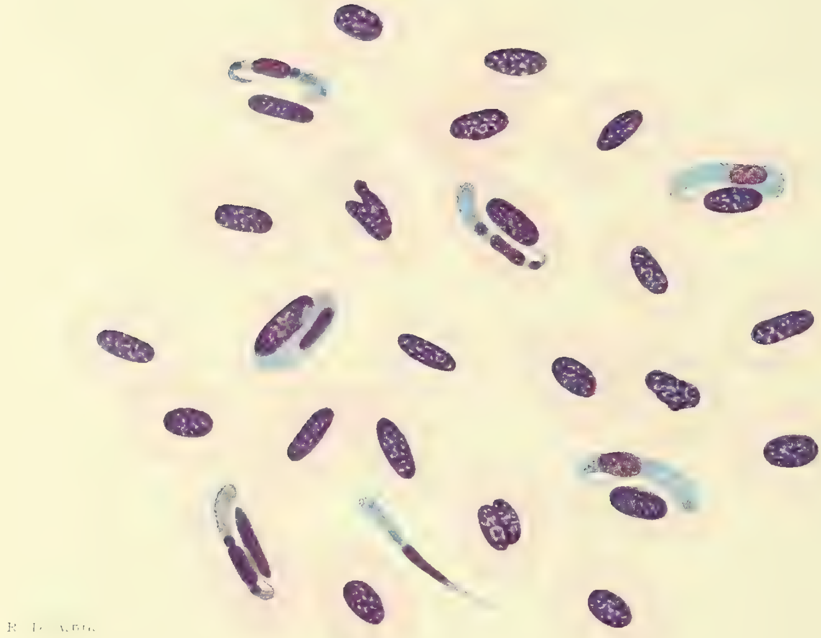
At the present time we cannot go further, but it is hoped, especially by cultural and possibly by therapeutic work, to clear up much that is confusing and doubtful. It is important to ascertain the precise species of trypanosomes present in the Sudan, for much may depend on this when preventive measures and treatment call for consideration. The French work is certainly very suggestive, but it is well to keep an open mind. In any case I believe the mule trypanosomiasis to be carried by the tsetse fly—chiefly by *G. morsitans*, and this for reasons fully explained in the last Report. It is perhaps worthy of note that Cazalbou is inclined to regard Baléri as a tsetse disease, the ass being the reservoir of the virus.

The suggestion made by Dutton, Todd and Kinghorn[1] referred to *T. nanum*. They asked if this trypanosome might not be merely the "tadpole" form of their *T. dimorphon*.

The short trypanosome, is it *T. nanum*?

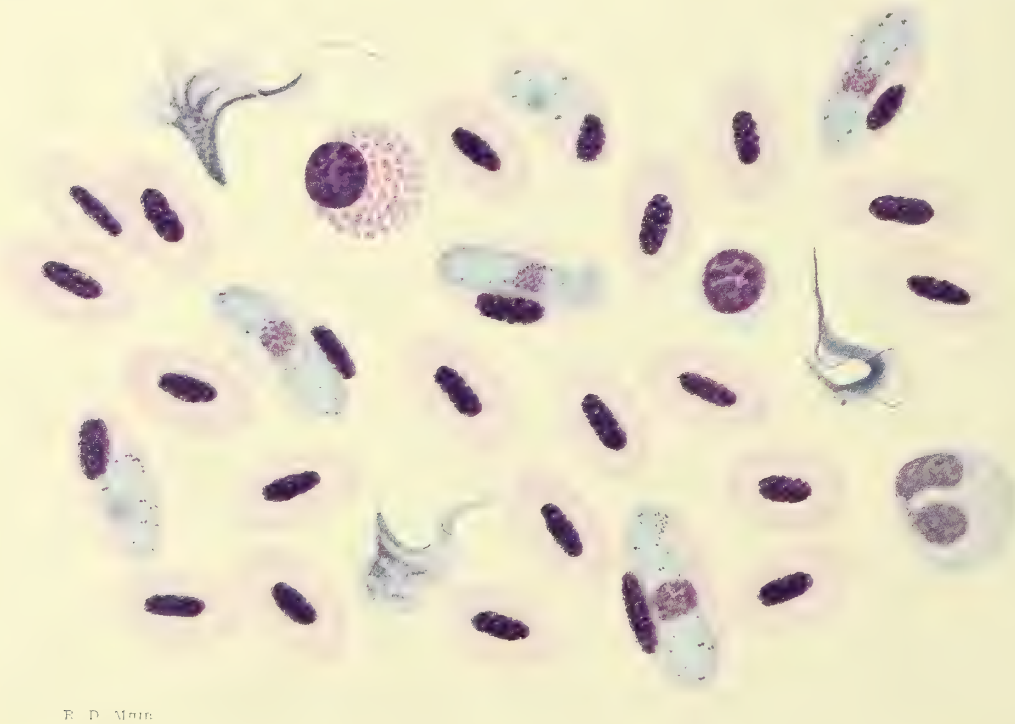
Dr. Wenyon's work on this parasite shows that this is unlikely. *T. nanum* is not always of the "tadpole" type, and now that dogs and a gerbil have been successfully inoculated, the available evidence tends to prove that it is a distinct species and that Laveran was correct in giving it a specific name. The disease produced by it differs from that caused by *T. dimorphon*, but the Liverpool observers suggest that the "tadpole" forms may be present in chronically infected animals, and that they give place to the "stumpy" and "long" forms as the disease becomes more acute, in either the original host or in sub-inoculated animals. Personally I have seen no evidence of this as regards *T. nanum*,

[1] Dutton, J. E., Todd, J. L., and Kinghorn, A. (June 2nd, 1907), "Cattle Trypanosomiasis in the Congo Free State." *Annals Liverpool School of Tropical Medicine*, Vol. I., No. 2.



Hæmogregarine of *Rhamphiophis rubropunctatus.* Encysted and free forms

Leishman Stain × 1000 *diam.*



Hæmogregarine and trypanosome of the Khartoum toad *(Bufo regularis)*

Giemsa Stain × 1000 *diam.*

which appears to retain its characteristic size and shape throughout the illness it induces. At the same time, I admit that the last word has not been said about this trypanosome either, and it is a pity that the laboratory strain obtained from Dr. Wenyon was lost at the time of the fire, as one had hoped to reach some definite conclusion regarding it. Doubtless, however, we will in time arrive at a correct understanding regarding all the different species found in the Sudan, and, for the present, Plate I., on which are grouped all those hitherto found, should materially aid those engaged in blood examinations and veterinary work.

Hæmogregarine of the Jerboa

By the Director

Hæmogregarina jaculi (Balfour)

According to the laws of nomenclature the above must be the name of the hæmogregarine of jerboas described in the Second Report, and not *H. balfouri* (Laveran) as there stated. Further observations have been made on this parasite, but all efforts to find an extra-corporeal stage in an insect host have met with failure. In the first place, however, one may consider the blood conditions. In the case of other hæmogregarines of mammals, notably *H. gerbilli* (Christophers) and *H. funambuli* (Patton), careful differential leucocyte counts have been made of the blood of infected and of non-infected animals. The discovery of uninfected jerboas *(J. gordoni)* enabled me to institute similar comparisons in the case of these rodents.

Differential leucocyte counts

In a jerboa with a large infection, I found the following percentages :—

Polymorphonuclears	40·4
Large mononuclears	57·8
Small mononuclears	1·4
Basophiles	0·4

In one with a very slight infection, where, after prolonged search, only one parasite was found in a large film, the percentage count was :—

Polymorphonuclears	62·2
Large mononuclears	34·4
Small mononuclears	0·0
Basophiles	3·4

Finally, in an uninfected jerboa, the percentages were :—

Polymorphonuclears	39·6
Large mononuclears	58·6
Small mononuclears	0·0
Basophiles	1·8

In each instance 500 cells were counted. From these and other observations it would seem that infection does not markedly alter the differential leucocyte count. Observations have been made on fœtal and newly-born jerboas, the progeny of infected mothers. These have invariably been found free from infection.

Young uninfected jerboas have been kept in the same mouse jar with their infected and flea-infested mother, but they did not acquire the parasite. This experiment was of nearly a fortnight's duration.

Failure to find insect host

A jerboa inoculated with the blood of an infected jerboa also failed to show the parasite, and experiments with fleas fed on heavily infected jerboas and then transferred, while still gorged with blood, to uninfected jerboas, proved negative.

Numerous experiments have been conducted with fleas, chiefly *Lœmopsylla cleopatræ*, mites (*Dermanyssus* sp.), and bed-bugs *Cimex macrocephalus* (Patton), with a view to finding an extra-corporeal stage in the life-cycle. All that has been noted, however, is that in all these insects there is a marked tendency to the formation of travelling vermicules. The sporonts are set free and become the slow-moving, worm-like forms described and figured in the last Report.

In this connection, attention may be directed to Plate II., which is taken from a section of a flea and shows the arrangement of *Crithidia pulicis* in the hind gut of *Lœmopsylla cleopatræ*, this being the *Herpetomonas* parasite of the flea itself, which was at first mistaken for a developmental stage of *Hæmogregarina jaculi*.

Hæmogregarine of Rhamphiophis Rubropunctatus

By the Director

Hæmogregarina vaughani, n.sp.

A snake parasite

In a blood-smear taken from the non-poisonous snake, *Rhamphiophis rubropunctatus*, in the Bahr-El-Ghazal Province, and sent me by Captain P. S. Vaughan, I found a hæmogregarine present (*vide* Plate III., fig. 1). I am indebted to Mr. A. L. Butler for having the snake identified for me. He tells me it is a rare one in collections.

Morphology

In the smears, endoglobular sporonts and free forms were found. The former were fairly numerous; the latter, rare. The parasites resemble *H. terzii* (Sambon and Seligmann). The sporont is curved, usually thicker at one end than at the other, and partially surrounds the corpuscular nucleus, which is often flattened and pressed close against the convexity of the parasite. The narrower posterior end of the sporont is sometimes incurved. The nucleus is usually central in position, but may be nearer one or other extremity. The extra-nuclear portion stains either a homogeneous blue (Leishman or Giemsa), or contains chromatin dots, sometimes of considerable size, or portions which stain a darker blue colour. One has specially noted the chromatin dots along the convex edge of the sporont and close to the nucleus. The parasite is either in close contact with the corpuscular substance or (and this is more common) lies in a well-marked capsule, like that which encloses *H. terzii*, the hæmogregarine of the boa-constrictor.

The sporonts vary in size. They are from 12·75 μ long by 1·5 μ broad, to 18 μ long by 5·25 μ broad. A common measurement noted was 15 μ by 4·5 μ. The host cell is, as a rule, enlarged both in length and breadth, but its staining reactions remain unaltered. Sometimes the nucleus of the corpuscle is found lying across or partly across the parasite, an appearance doubtless produced artificially in making the smear.

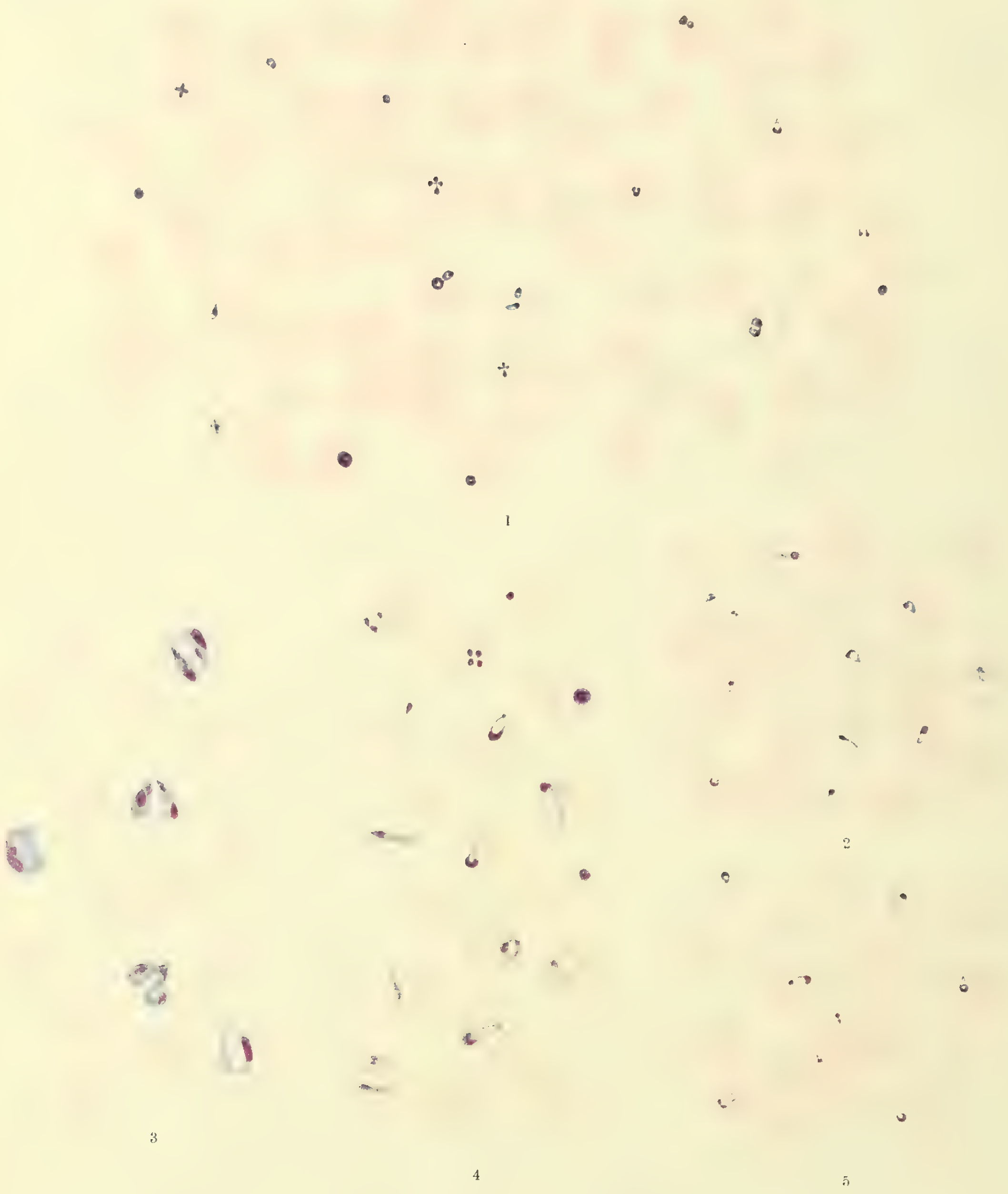
Free forms

The free forms are usually curved and attenuated. They vary in length from 15 μ to 18 μ, in breadth from 1·5 μ to 2·25 μ. The nucleus of the free form is longer than that of the sporont, measuring from 7·5 μ to 10·5 μ in length. I have seen no granules or dots in the extra-nuclear portions of these vermicules.

As only a single film was available, one was unable to carry out different staining methods or vary the intensity of the stain. The oblique, transverse lines, described by Sambon and Seligmann in *H. samboni* (Giordano), and other forms, were not observed, nor was there any marked indication that the sporonts were sexually different, although it is true that the smaller forms did not present the granules and dots shown by the larger ones, and that the protoplasm of the former had more of a hyaline appearance. The schizogony and sporogony of this hæmogregarine are unknown.

I propose the name *H. vaughani* for this hæmogregarine.

PLATE IV



Bovine Piroplasmosis

1. Small parasite from Berber Province
2. Small parasite from Kassala Province
3. *Piroplasma bigeminum*
4. *Piroplasma mutans*
5. Parasite of Egyptian fever of cattle, Cairo (Bitter)

Giemsa Stain × 1000 *diam.*

Spirochætosis of Sudanese Fowls

By the Director

Historical

It will be convenient in the first instance briefly to review the work accomplished on what was originally termed Fowl Septicæmia or Brazilian Septicæmia of Fowls, an illness due to the presence of *Spirillum* or *Spirochæta gallinarum* [1] in the blood of these birds.

The disease in Brazil

1. Marchoux and Salimbeni,[2] working in Brazil, were the first to describe the condition. They noted that special varieties of fowls were more apt to be attacked, and were more severely attacked than the common species. They distinguished an acute and chronic form of the disease, the former characterised by wasting, somnolence, diarrhœa, ruffled feathers, anæmia, as evidenced by pallor of the comb, weakness, so that infected birds cannot perch, and towards the end are found lying helpless with their heads on the ground. Death occurs accompanied by spasm. The chronic form follows the acute. There is an appearance of return to health, then a relapse, paralysis of the feet and of the wings, progressive emaciation, and death in eight to fifteen days. Recovery may occur, but sometimes paralysis remains as a sequel to the illness.

In the acute form there is fever, the temperature ranging from 108° F. to 109° F. for four or five days. It then falls to about 107° F., *i.e.* slightly subnormal, returning to normal if recovery takes place. It remains low if there be combined cachexia.

They showed that the disease was associated with the presence of a spirillum in the blood, the morphology of which they did not describe, but which Laveran named *Sp. gallinarum*,[1] and that this organism was conveyed from sick to healthy birds by the bites of *Argas* ticks. They proved that in tick-bite infection the incubation period was four to nine days, and ticks were stated to be a sure and certain means of inoculation, and to transmit a severe form of the disease. Ticks were found to be capable of producing infection five months after their last feed on an infected bird. When a healthy fowl was inoculated subcutaneously with a few drops of infected blood from a sick bird, infection was found to occur, the incubation period being short, a rise of temperature being apparent after twenty-four hours, and spirilla[3] being present in the blood. There was no reaction at the point of inoculation. In the acute disease the spirilla were found to multiply in the blood until the infection reached a maximum. At this time the temperature was found to fall, and the spirilla, which were at first separate, to accumulate in masses. Small masses were noted to unite and form large groups, chiefly found at the extremity of a blood film. The so-called crisis, really a short lysis, was stated to take place a short time after the formation of the large clumps which, in acute and fatal forms, very slightly preceded death. If recovery ensued, it took twelve or fifteen days for the fowl to regain its former weight. The French observers stated that after the crisis the spirilla vanish from the circulation and do not again appear in it—not even in those cases which prove fatal. They further noted that a chronic disease associated with atrophy of the internal organs (liver and spleen) may follow experimental inoculation.

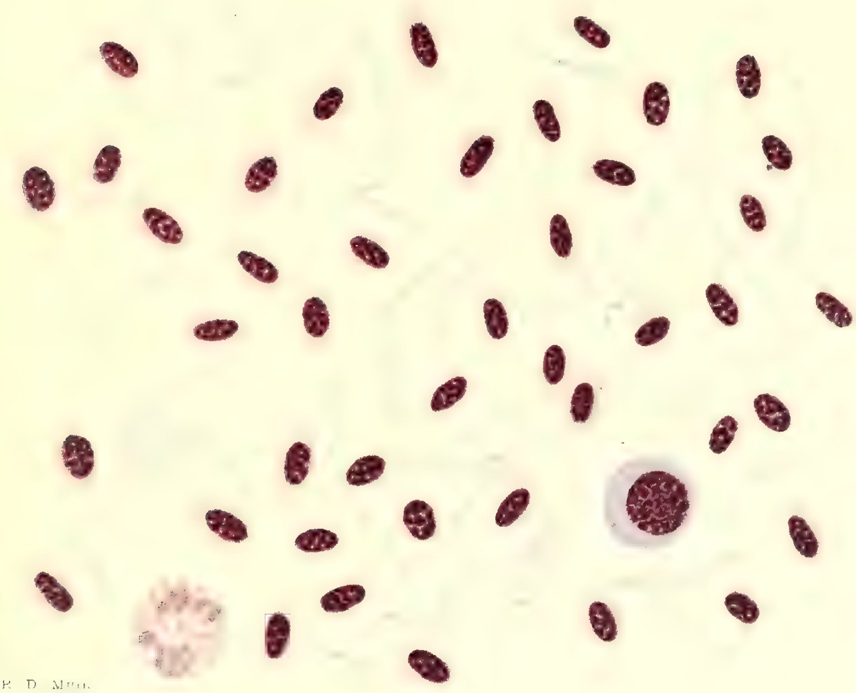
They recorded the post mortem signs as great enlargement of the spleen, often to thrice its normal size, some enlargement of the liver associated with fatty degeneration, and areas of necrosis. The other organs are unaffected.

They found that no young fowl was absolutely refractory to the disease; that geese were very susceptible, dying in five or six days; that ducks and guinea fowls were also susceptible; that turtle doves and sparrows take the disease and die; while in pigeons the illness is slight,

[1] Recently re-named *Sp. marchouxi* by Nuttall.

[2] Marchoux, E., and Salimbeni, A. (September 25th, 1903), "La Spirillose des Poules." *Ann. de l'Institut Pasteur*, pp. 569–580, Vol. XVIII.

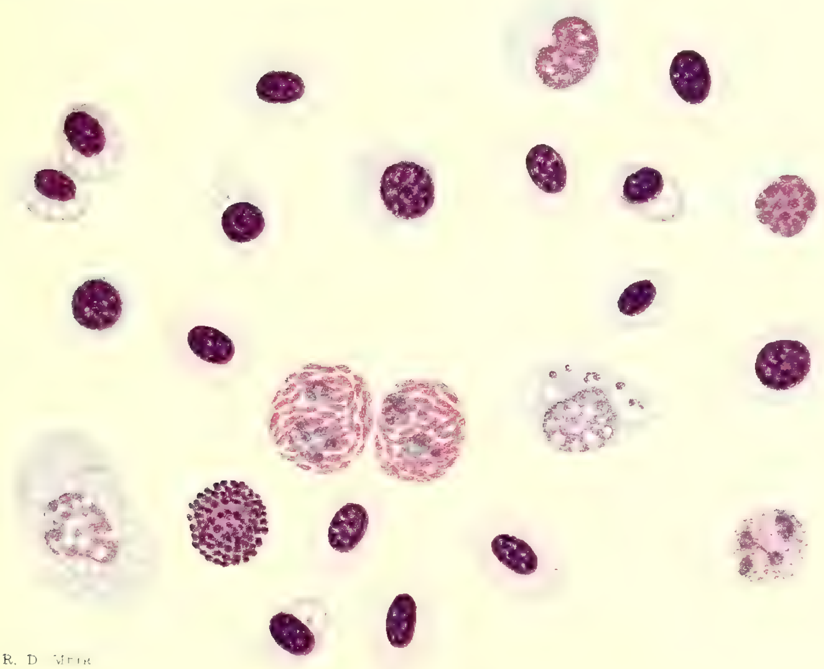
[3] Now termed Spirochætes, their protozoal nature being generally admitted.—(A.B.



Fowl Spirochætosis

Free spirochætes and tangles during the acute stage

Giemsa Stain × 1000 *diam.*



Fowl Spirochætosis

Types of leucocyte in the peripheral blood and polychromatophilia of the erythrocytes. Large, vacuolated mononuclears

Giemsa Stain × 1000 *diam.*

and no spirilla can be demonstrated in the blood. The guinea pig was found to be insusceptible, and in monkeys only a local œdema followed inoculation.

It was shown that fresh serum acted in the same manner as infected blood, that the spirilla agglutinate very rapidly in serum, and that after 48 hours all their movements cease and the serum ceases to be infectious. Such serum possesses immunising properties, and this power is destroyed in twenty minutes by a temperature of 55° C. Serum passed through a Berkefeld filter loses its virulence, but possesses immunising properties.

The question of immunity

A fowl which has recovered from the disease was found to possess an absolute immunity. Thus 2 c.c. of blood from a fowl recovered for a period of one month, given 48 hours before a virulent injection, wholly protected from infection. There was not even elevation of temperature or loss of weight. A second injection only produced a transient effect. Preventive serum mixed with virulent serum for five minutes rendered the latter harmless, as a general rule.

Work by Levaditi

2. Levaditi[1] then took up the subject and obtained rather different results. He found the guinea fowl was refractory—showed that the crisis was, properly speaking, a lysis, and that death might occur either before or after this lysis. In the inoculated disease he found the illness usually lasted four to six days before the lysis occurred. Other points noted by him were:—

(*a*) Young fowls never show the lysis, but die three to eight days after inoculation.

(*b*) In tick infection the incubation period is five to six days.

(*c*) There is no local multiplication of spirilla—*i.e.* at site of inoculation. They divide transversely.

(*d*) The disappearance of the spirilla is not associated with phagocytosis in the peripheral blood. This is accomplished by the macrophages of the spleen and liver. Sometimes red blood corpuscles or their free nuclei are taken up by the leucocytes.

(*e*) A susceptible young fowl inoculated with defibrinated blood, 26 hours after lysis, and apparently quite free from spirilla, became infected. This showed that spirilla were present, though they could not be demonstrated.

(*f*) A mono- and sometimes a polynuclear leucocytosis, together with basophilia of the erythrocytes, and the presence of large (splenic?) vacuolated mononuclears in the blood. These increase in numbers before the so-called crisis.

(*g*) The agglutination is not permanent, the spirilla regaining their freedom in from 4 to 35 minutes. False clumping is probably due to the abrupt change produced when the blood is taken for examination.

(*h*) True agglutinins and immobilisines appear after the crisis.

(*i*) No granular transformation of spirilla occurs. Levaditi also discussed the cause of the crisis and opposed the view of Gabritschewsky,[2] who, as regards *Sp. anserina,* believed that it was brought about by anti-bodies in the blood. Levaditi upheld the phagocytic theory, pointing out that the last spirilla remaining in the circulation are wholly unchanged, and advancing experimental proof to show that his theory regarding the splenic and hepatic macrophages fully explained the mechanism. These arguments need not be given in detail.

The disease in geese

3. Sakharoff[3] had previously discovered a similar disease attacking geese in the Caucasus. He named the spirillum *Sp. anserina*, and found that it was pathogenic for

[1] Levaditi, G. (March 25th, 1904), "Contributions à l'Étude de la Spirillose des Poules." *Ann. de l'Institut Pasteur*, Vol. XVIII.

[2] Gabritschewsky, G. *Cent. f. Bakt.*, Vol. XXIII., Nos. 9–18; Vol. XXVI., Nos. 10, 16, 17; Vol. XXVII., No. 2.

[3] Sakharoff, G. P. *Ann. de l'Institut Pasteur*, p. 564, Vol. V.

the young chicken, though, according to Cantacuzène,[1] the fowl rarely succumbs. The disease induced is very like that caused by *Sp. gallinarum.* Yellow caseous granulations are found in the liver post mortem.

4. Borrel[2] was the first to demonstrate by a special and somewhat intricate process the apparent presence of peritrichous flagella in *Sp. gallinarum.* I think the present tendency is to regard the appearance as of the nature of an artefact.

5. Levaditi and Manouelian[3] further investigated the subject, and concluded that—

(i.) Brazilian septicæmia is not exclusively due to a proliferation of *Sp. gallinarum* in the blood. The parasite invades the various glandular tissues, and enters into intimate contact with the divers cellular elements. Unlike *Treponema pallidum,* however, it does not seem to penetrate into the protoplasm of the cells.

(ii.) The crisis is due to phagocytosis by the macrophages of the spleen and liver.

(iii.) The parasite can infect the egg of the bird inoculated experimentally.

6. At a later date, Levaditi[4] entered into the question of the disease in the embryo of the fowl. One need not follow him into this field, but merely note his conclusions that—

Hereditary transmission

(i.) Spirillosis is not hereditarily transmissible to embryos born of infected fowls. This is possibly because infected eggs may not be capable of fecundation and segmentation, or because the spirilla which have invaded them may die off during the long process of the "birth" of the egg.

(ii.) These embryos are immunised against infection by *Sp. gallinarum,* this immunity being probably of a passive nature.

It is in this paper also that he explains the death of adult fowls which have survived the crisis as due to the action of a toxin liberated from the spirilla after their death in the protoplasm of the phagocyte.

7. So far as I can find out, spirillosis occurring naturally in poultry was not described, save in Brazil, until I[5] encountered it in Khartoum fowls towards the close of 1906.[6] This is the disease forming the subject of the following paper. (*See page* 44.)

The disease in India

8. Reaney,[7] having noted this discovery, looked for and found the disease in fowls at Agar, in India, and, in the course of his second paper, mentions that Bannerman had found a spirillum in a chikor partridge in the Bombay Zoological Gardens. He thinks the tangles of spirilla may be the result of rapid division.

9. Montgomery,[8] also in India, was the next observer. Apparently he had not noticed the Sudan work or Reaney's paper, for, after mentioning Marchoux and Salimbeni's discovery, he says: "Its occurrence in other parts of the world has not since been noted"; but, in the course of his own, he mentions that Pease had observed a disease in ducks at Lahore, which he attributed to spirochætes observed in the blood. Montgomery describes the parasites as being, as a rule, from 7 to 9 μ in length, and

[1] Cantacuzène, J. (1899). *Ann. de l'Institut Pasteur.*

[2] Borrel, A. (January 20th, 1906), "Cils et division transversale chez le spirille de la poule." *C. R. de la Soc. de Biol.*

[3] Levaditi, G. Y., and Manouelian (November 25th, 1906), "La spirillose des embryons de poulet." *Ann. de l'Institut Pasteur.*

[4] Levaditi, G. Y. (November 25th, 1906), "La spirillose des embryons de poulet." *Ann. de l'Institut Pasteur,* Vol. XX.

[5] Balfour, A. (March 30th, 1907), "A Spirillosis, etc., of Domestic Fowls in the Anglo-Egyptian Sudan." *British Medical Journal,* p. 744, Vol. I.

[6] Nuttall, however, in his Harben Lectures for 1908, states that Bitter informed him that spirochætosis occurs in fowls round about Cairo, and that the condition has also been reported from Australia.

[7] Reaney, M. F. (May 11th, 1907), "Spirillosis of Domestic Fowls." *British Medical Journal,* Vol. I. *Ibid.* (November, 1907), *ibid. Indian Medical Gazette.*

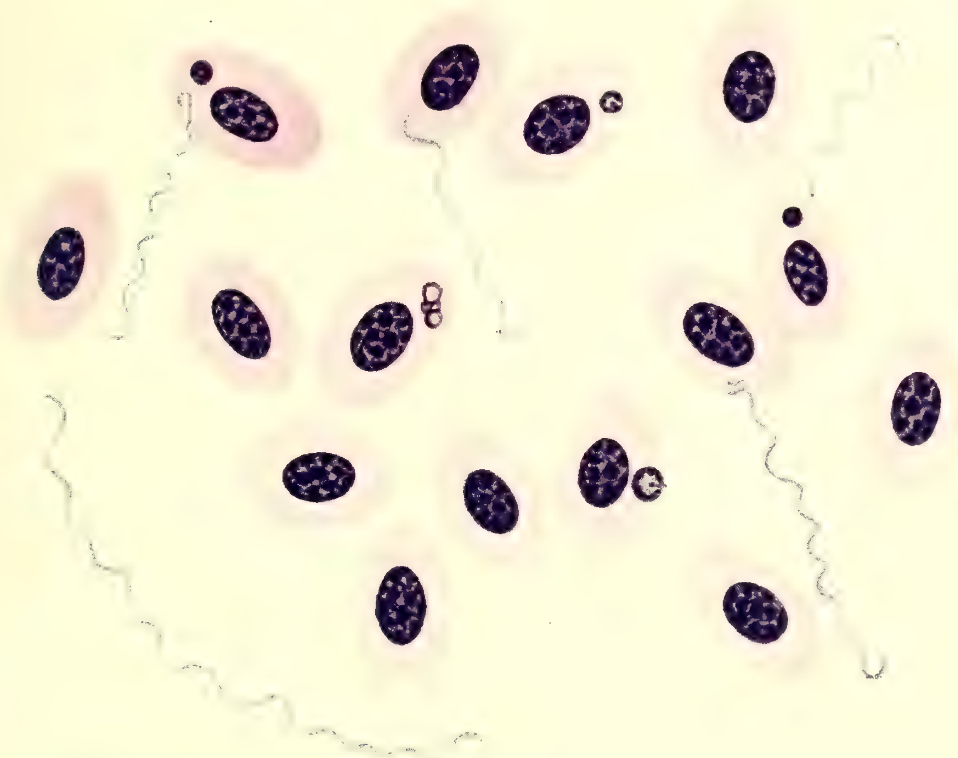
[8] Montgomery, R. E. (February, 1908), "On a Spirochæte occurring in the Blood of Chickens in India." *Journal of Tropical Veterinary Science,* Vol. III., Pt. I.

PLATE VI

Fowl Spirochætosis

Intra-corpuscular forms of spirochætes constituting the "after phase" of fowl spirochætosis

Giemsa Stain × 1000 *diam.*



Fowl Spirochætosis

Free and intra-corpuscular forms of spirochætes co-existing in the peripheral blood of a fowl after the so-called crisis

Giemsa Stain × 2000 *diam.*

possessing from six to ten spiral turns. Long or combined forms, 30 μ in length, and containing fewer spirals as compared with their size, were also noted. The extremities taper and stain faintly. Breaks occur in the stained parasite. They are irregular in situation. As many as twelve were seen in one of the combined organisms situated at distances varying from $0{\cdot}2\,\mu$ to $1{\cdot}5\,\mu$. In a single organism they were found at about $1\,\mu$ apart. The author speaks of the core and periplast described by others. He had no opportunity of confirming or confuting Borrel's work on peritrichous flagella. He notes the disease terminates by lysis, not crisis, and found that continued passage through fowls appeared to modify the disease and the virulence of the organism. Some chickens which were found to be insusceptible to inoculation appeared to possess a natural immunity, as certain of them were only ten days old. Montgomery considers the geographical distribution of this disease, and that of human spirochætosis in India, to be at least suspicious.

10. Next in the field came Bevan[1] with a description of the disease in Southern Rhodesia. There it is most prevalent during the spring months of November and December, possibly because the climatic conditions are then most favourable for the hatching out of the eggs of ticks, while the ticks themselves are more plentiful. It was noticed that apparently immune birds succumbed when the infection had been re-started by the introduction of new susceptible birds to the poultry run. Bevan suggests that this is due to the parasite having gained in virulence (*vide infra* No. 12). In the most acute cases the birds seem to die in one night. He deals with preventive measures, advocating the spray pumps of the Deeming Company, Ohio, as suitable for distributing liquid insecticides. The residue from calcium carbide after the production of acetylene gas is said to be useful for whitewashing fowl-runs. The disease in Rhodesia

He describes tick-proof fowl-houses—perches slung on wires—poles surrounded by vessels containing petroleum, etc. Oil dressing of fowls is mentioned, as is dipping the birds in weak Cooper's dip. Preventive measures

Atoxyl was tried as a curative agent, and seemed to benefit some cases which were *in extremis*.

11. Williamson[2] has a paper on spirochætosis of fowls in Cyprus. The disease is endemic there and occurs in the hot months—June, July and August. It is most prevalent where the poultry runs are small and contain old, and therefore dry, manure. It is rare where the birds are allotted plenty of space. The dry manure forms a suitable hatchery for tick eggs, and is a good dusting-place for the fowls. The disease in Cyprus

The symptoms are characteristic, but the tick concerned is *Argas reflexus*, not *A. persicus* Tick concerned in transmission

The disease, which appears to attack ducks, does not seem to be transferable to man, two cases being cited in proof of this conclusion.

12. Marchoux,[3] like Bevan, noted the loss of virulence on passage, but found that it was maintained under natural conditions by passage through *Argas miniatus*. (This is merely a variety of *A. persicus*.)

13. Fülleborn and Mayer[4] have found that *Ornithodoros moubata* is effective as a transmitter of *Sp. gallinarum*, the tick having been found infective for 103 days after biting a diseased bird. There is, therefore, no specific relation between the tick and the species of spirochæte. The human tick effective

[1] Bevan, Ll. E. W. (March 1908), "Spirillosis of Fowls in Southern Rhodesia." *Journal of Comparative Pathology and Therapeutics*, Vol. XXI., Pt. I.

[2] Williamson, G. A. (June 15th, 1908), "Spirochætosis of Cypriote Fowls." *Journal of Tropical Medicine and Hygiene.*

[3] Marchoux, E. (October 12th, 1907), "Instabilité de la virus des Spirilles et sa fixation par l'hôte invertébré." *C. R. de la Soc. de Biol.*, Vol. XII.

[4] Fülleborn, and Mayer, M. Quoted in *Bull. de l'Institut Pasteur*, March 30th, 1908.

14. Schellack,[1] like Williamson, has obtained definite proof that *Argas reflexus* is effective. This species of tick has been found capable of infecting 64 days after feeding on spirochætal blood.

15. Levaditi along with Roche[2] again affirms that the crisis is entirely due to phagocytic action, and not to bacteriolysins and opsonins. The latter appear to be the result of the destruction of the parasites, not the cause thereof.

Action of atoxyl

16. Together with McIntosh,[3] the senior author advances, in proof of this theory, the action of atoxyl, which exerts its beneficial effect, not by any direct attack on the parasites, on which it has no action *in vitro*, but by a stimulation of phagocytes, thus in reality bringing about a "precocious crisis."

Work on immunity

17. Neufeld and Prowazek[4] do not agree with Levaditi. They think that both the immunity and the spirillicidal power are due to the intervention of a thermolabile non-specific complement and of a specific amboceptor. It was they who first endeavoured to show that spirochætes are really protozoa by observing the action of bile salts and saponin or sapotoxin upon them. While the spirochætes are destroyed by these substances, bacteria, except the pneumococcus, are not affected.

These authors discuss the disease very fully, and repeated much of the work. They found that, after artificial infection, the spirochætes appear on the third day. They are in great quantity on the fifth day, when they form tangles. The agglomeration is like that undergone by trypanosomes, but is not the same, as there is an irregular distribution in the heaps. After the fifth day motility decreases, becoming convulsive in nature. At the crisis (seven to eight days) the parasites disappear *almost completely*.

There is leucocytosis, destruction of red blood cells, jaundice, and an increase in erythroblasts towards the crisis.

The serum of "salted" birds possesses a marked anti-parasitic action. It agglomerates spirochætes in 1 in 500, and kills them in 1 in 1000. Spirochætes thus treated stain badly. No opsonins are to be found. No phagocytosis takes place in mixtures of leucocytes, spirochætal blood, and inactivated immune serum; but no experiments were made with fresh immune serum! There is, however, loss of pathogenicity.

The disease is prevented if 0·0025 c.c. immune serum be injected into fowls 24 to 48 hours before inoculation. If this is done during the disease, agglomeration of the spirochætes occurs, and death from extensive thrombosis, as was, indeed, noted by Levaditi.

There are no toxines produced. The filtrate from a Berkefeld filter produces no disease. The pathogenic action seems to be due to the great numbers of parasites and their destructive effect on the blood-vessels.

18. Uhlenhuth, Gross and Bickel[5] found that atoxyl in 5 centigram doses could prevent the disease or cure it if given at the time of, or one or two days after, inoculation. The blood, however, remains infective. Fowls cured, or in which the disease has been prevented developing, are immune. Quinine is said to be also beneficial.

There is another special paper by von Prowazek which will be mentioned later, as it deals with some of the conditions specially described in the following paper.

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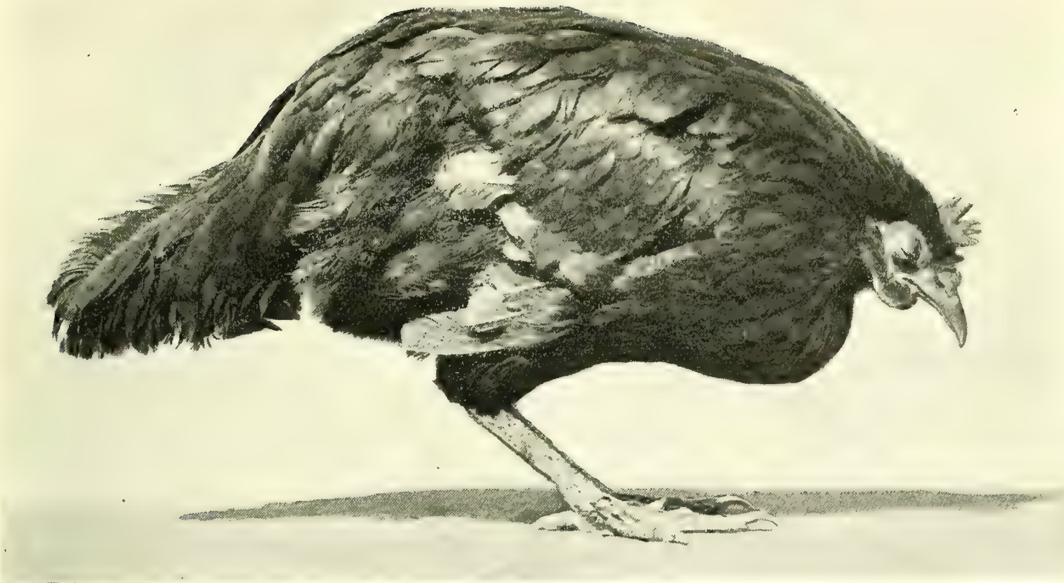
[1] Schellack, C. (April 18th, 1908), "Uebertragungsversuche der *Spirochæte gallinarum* durch *Argas reflexus*" (Fabr.). *Cent. f. Bakt. Orig.*, Vol. XLVI., No. 6.

[2] Levaditi, G., and Roche, J. (1907), "Les opsonines et le mécanisme de la crise dans la Tick fever." *C. R. de la Soc. de Biol.*, pp. 619–621, t. LXII.

[3] *Ibid.* and McIntosh, J. (June 15th, 1907), "L'influence de l'atoxyl sur la spirillose provoquée par le Spirillum Gallinarum." *C. R. de la Soc. de Biol.*, t. LXII.

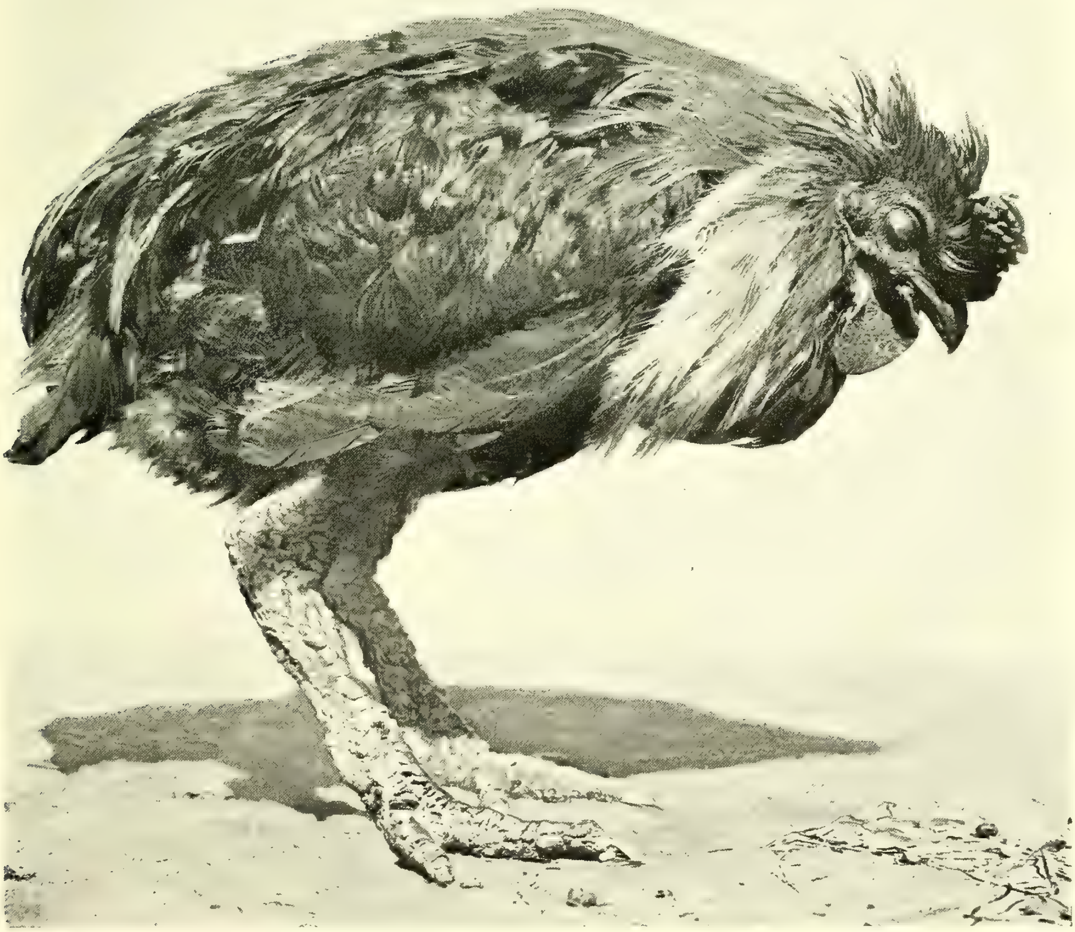
[4] Neufeld, F., and Von Prowazek, S. (1907), "Ueber die Immunitätserscheinungen bei der Spirochæten-septikämie der Hühner," etc. *Arb. a. d. Kaiserl. Gesundheitsamte*, Vol. XXV., No. 2.

[5] Uhlenhuth, Gross and Bickel (January 24th, 1907), "Untersuchungen über die Wirkung des Atoxyls auf Trypanosomen und Spirochäten." *Deut. Med. Woch.*, p. 128.



W. Beam

Fig. 4.—Black Leghorn Hen suffering from Acute Spirochætosis



W. Beam

Fig. 5.—Sudanese Cock in the "after-phase" of Spirochætosis and suffering also from "Scaly-Leg"

It was in November, 1906, that I received three black Leghorn fowls from the Grand Hotel, Khartoum, which, from the symptoms they presented, I thought might be suffering from a spirochætosis. Microscopical examination of the blood confirmed the diagnosis.

The disease in imported fowls

As there was no record of this disease having been described elsewhere than in Brazil, I thought it possible that these birds, which had been recently imported from Italy, might have come in contact with infected fowls from South America. I obtained the history of their purchase, and found that 10 black Leghorns had been bought at Rapallo, five Brahmas at Ciavari near Rapallo, and four Brahmas from Politza, on October 22nd. They had been shipped at Genoa on the 24th, and had arrived at Port Sudan on November 1st. One Leghorn and three Brahmas had died in the Red Sea. Some of the birds had suffered from diarrhœa on the voyage. They arrived at Khartoum on November 10th, when they were apparently well, except one Brahma cock. On November 3rd, ticks were found upon them and they were oil-dressed. By November 21st they were all dead, except the three which were then sent to me, and which were extremely ill. The history forthcoming was that they had suffered from diarrhœa, and that they kept their heads low as though weak. They had taken food fairly well. It was also reported that all the native chickens with them in the fowl-run were apparently quite well, and that no pigeons were affected.

The endemic disease

Subsequent inquiries and examinations showed, however, that there was no need to consider the question of infection during transit. Spirochætosis was found to be a common disease in Sudanese fowls, the hen-run at the hotel was discovered to be swarming with *Argas persicus*, and no doubt the reason why these imported fowls presented the disease in such an acute and grave form was because they belonged to special breeds, which, as Marchoux and Salimbeni pointed out, suffer much more severely than the common varieties.

It may be said at once that, out of some 100 common Sudanese fowls examined in varying stages of the disease, I do not think I have seen any affected as severely as these imported birds. The Sudan fowls tend to pass into a special chronic stage, hereafter to be described, and rarely succumb with the rapidity which characterised the fatal issue in the black Leghorns.

Symptoms

Symptoms.—Fig. 4 gives a good idea of the aspect of one of these birds in the last stages of the acute disease. Note the drooping head, the ruffled feathers, the closed eyes, the somnolent aspect. Fig. 5, which presents a similar aspect, is that of a Sudanese cock, also in a dying condition, but suffering from the chronic type of the disease which, as will be shown, is characterised by the presence of intra-corpuscular forms of the spirochætes which invade the red blood corpuscles, wherein they appear to pass a resting stage. Both in the acute and chronic forms there exist anæmia and emaciation, while diarrhœa is not uncommon. Towards the end the legs give way from weakness, or possibly true paresis, and the hapless bird lies prone on the ground, along which its neck is stretched, and it is unable to raise its head. In fact, the whole clinical picture answers to that described in the case of infection by *Sp. gallinarum*. The spirochætes exist in large numbers in the peripheral blood of imported fowls. In fresh films their movements are exceedingly rapid, and at first, as a rule, one only recognises their presence by the agitation they produce amongst the red cells. When one has become more accustomed to the field of vision the combined darting, rippling and shivering movements become evident, and the parasites are seen every now and then speeding across the field. Very frequently one gazes at a field which one knows is full of spirochætes, and yet no trace of them can be seen till suddenly a tiny, semi-translucent corkscrew form quivers into sight for a second and as speedily vanishes. There is no great difficulty, however, in the case of a heavy infection, but in Sudanese fowls, where it may be very slight, prolonged and careful examination is required. It must not be too prolonged, for the spirochætes, after a varying but comparatively short time, lose their motility when kept

Morphology of the spirochætes

between slide and cover glass. They are more easily recognised in preparations stained by the Giemsa or Leishman methods, the former being on the whole the more satisfactory. I employ the made-up fluid Giemsa, supplied by Grübler in a strength of 7 drops of the stain to 4·5 c.c. of distilled water. The film is fixed for ten minutes in absolute alcohol, then placed film side down in a special staining dish or in a shallow Petri capsule with its ends supported by tiny glass rods (broken pieces of vaccine capillary tubes serve the purpose) and the stain is poured in. Staining is continued for a quarter of an hour or longer, the film is washed, dried, and examined under a $\frac{1}{12}$-in. oil immersion. Staining for five or even ten minutes is usually insufficient, and, as will be seen, led to mistakes being made and caused erroneous impressions. Plate V., fig. 1, shows the different aspects presented by the stained parasite. Staining methods

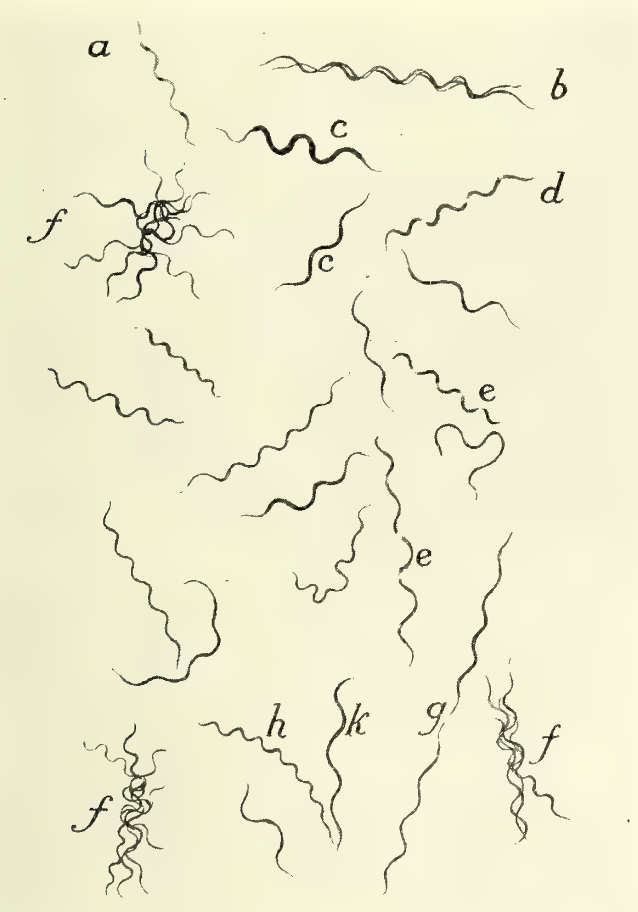


Fig. 6.—Forms of Fowl Spirochæte in the peripheral blood

In Fig. 6*a* shows a form in which three chromatic dots are clearly visible. They occur in the course of the nuclear helix, for as in other spirochætes the nucleus is diffuse, and examination with the highest powers of the microscope shows that there is a central nuclear core surrounded by a periplast. I think it is this periplast which gives the appearance of an undulating membrane described by Prowazek for *Sp. gallinarum*, while a frayed, fragmented periplast doubtless furnished the peritrichous flagella demonstrated by Borrel. In *a*, as in all the other forms, the pointed ends of the parasite are well seen; *b* shows an appearance which suggests longitudinal division. I have never seen transverse division occur in this spirochæte; *c* is one of the short thick forms, which some have supposed to be a female gamete. Another not quite so broad is also shown. Both *d* and *e* represent types of the parasite in which there are breaks or gaps in the central core, the nature of which is considered later; *g* is one of the long combined forms in which it would seem two spirochætes are united by their extremities; while *h* shows a fairly long thin form, claimed by some to be a male gamete, in which the spiral turns are small and numerous; and *k* is a form of similar length, but with only a few large spirals; *f* shows clumps of the parasites in the condition of pullulation preceding the crisis. The remaining drawings show common forms, either outstretched or curved and looped. Various forms of parasite

As regards size, there are short forms containing 4 spirals and measuring 9 μ in length, medium forms with 5 spirals and a length of 12 μ, fairly long forms with 8 spirals like *h*, measuring 16·5 μ in length, a very frequent size, and extra long forms with as many as 9 spirals and possessing a length of 19·5 μ. In addition, there are the combined forms exhibiting the appearance of a thin filament in the centre where the two parasites are in opposition by their fine extremities. The types of leucocyte found in the infected blood are shown in Plate V., fig. 2. Large, vacuolated mononuclears, like those described by Levaditi, are present, and so are basophilic lymphocytes. In the chronic stage I am inclined to think that there is constantly an eosinophilia. In some cases it is certainly very marked. In a bird dead of the acute disease but little is found post mortem. There is marasmus, evidence of anæmia and congestion, and enlargement of the spleen—the organ varying much in size. Sometimes the liver is also congested and enlarged. All the embedded specimens of organs—lung, spleen, liver, kidneys and lymph glands—were, as stated, lost in the fire, and one has not been able to study the histo-pathology of the acute disease to any extent. Nor has it always been easy to secure fowls showing spirochætes in their blood, while, owing to the fact that many Sudanese fowls possess a natural or acquired immunity, it was difficult to maintain the strain.

The leucocytes

Inoculation of the blood of one of the Leghorn fowls into a gerbil gave negative results.

As in Brazilian septicæmia, so here, there is what may be called a crisis prior to which the spirochætes agglutinate into clumps, and immediately after which they are not to be found in the blood by ordinary methods of examination.

The temperature, as a rule, is high, about 109° F., and falls at the crisis. The post-critical aspect of the disease will be discussed separately, as it presents special points of interest.

In the case of the Leghorn fowls, numerous larvæ of *Argas* ticks were found clinging to the bare patches under their wings. An apparently healthy Sudanese fowl was put into the infected hen-run, and in two days showed spirochætes in its blood. It was put into the fowl-house on December 4th, on December 6th it was found infected, but not severely, and by December 9th all parasites had disappeared from its peripheral blood. It continued to improve, but on the 17th was found to have passed into what I have termed the "after phase" of the infection, and ran a chronic course with eventual complete recovery.

Several other experiments showed that the tick was effective. In one instance a female tick, fed on a fowl with spirochætes in its blood, was dissected after Christophers' method, and the entry of a spirochæte into one of the eggs was observed, or at least an appearance very suggestive of this procedure.

Incubation period

The incubation period in experimental inoculation seems to be about forty-eight hours. It is difficult to determine the time accurately, as at first the infection is usually very slight, and may not be recognised until the parasites have multiplied considerably in the blood. I found no local multiplication, *i.e.* at the site of infection. As regards other birds, I recently found a spirochætosis in geese at Khartoum North, which I have reason to believe is due to the same parasite, and in which there is an "after phase" precisely similar to that occurring in the fowl disease. I have never found pigeons affected, and I have not used them in experimental work. Dr. Wenyon found guinea fowls on the White Nile with spirochætes in their blood, and discovered infected fowls in the Southern Soudan, so that probably the disease is wide-spread. We now know that a specific tick is not required for *Sp. gallinarum*, and that three species of *Argasidæ* can transmit that parasite. It is quite probable that several are operative in Sudan spirochætosis, but so far *Argas persicus* only has been proved to be a carrier.

The disease in guinea fowls

I have several times tried to inoculate gerbils, but have invariably failed. It is probable that this is an avian spirochætosis, non-transmissible to mammals.

The "after phase"

After phase.—We will now consider certain curious appearances found in the blood of sick fowls, the precise nature of which was at first unknown, but which eventually proved to be constantly associated with spirochætosis, and indeed to constitute a phase in the clinical picture of the disease.

While looking for fowls suffering from spirochætosis, I found a large proportion of birds in the Khartoum market exhibited intra-corpuscular bodies in their blood, the erythrocytes only being affected. Such birds might be brought in very ill indeed, with symptoms closely resembling those seen in spirochætosis, as in the case of the cock shown in Fig. 5. This photograph was taken when the bird was practically *in extremis*, exceedingly emaciated and somewhat dyspnœic. The condition of the legs and feet is due to infection by the ascarid *Sarcoptes mutans*, and has nothing to do with the general disease.

On the other hand, the birds, when the infection is slight, may scarcely show any sign of illness, though as a rule some emaciation is evident when one palpates the breast. It was soon apparent that the condition ended either in complete recovery or in death. In the

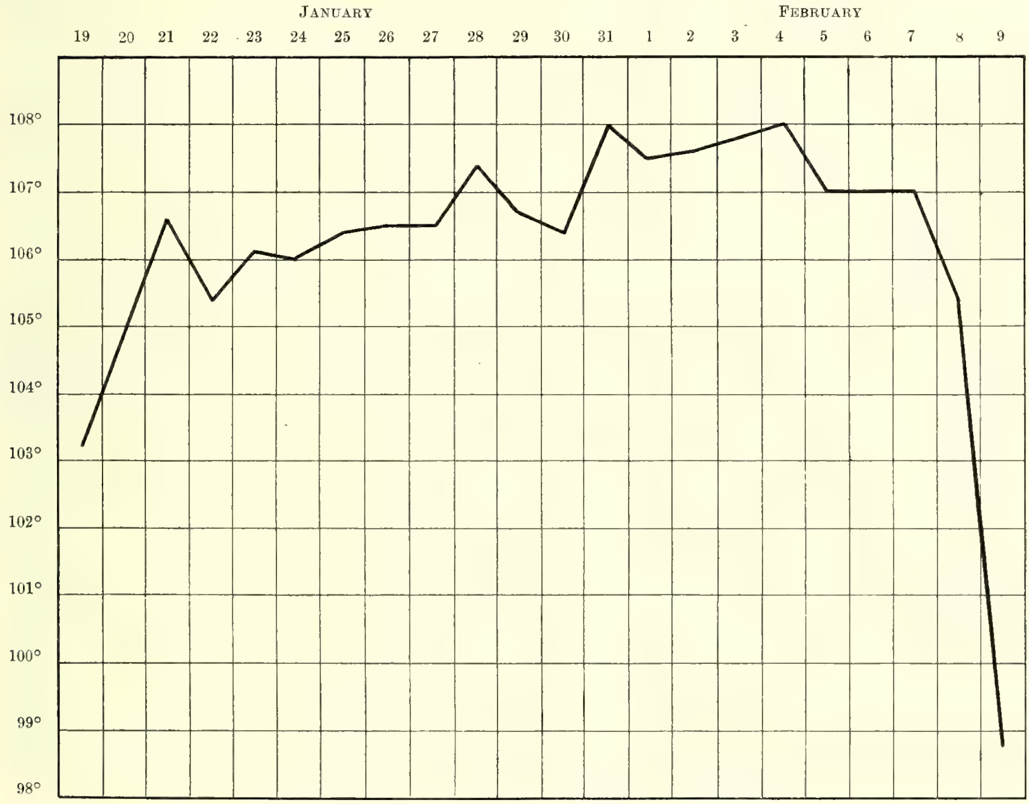


Fig. 7.—Chart showing temperature changes in spirochætal fever

former case the bodies entirely vanished from the corpuscles and the birds became strong and healthy; in the latter, the bodies might either remain about the same in number, or might rapidly increase both as regards infection of different red cells and as regards multiple infection of individual red cells, and the unfortunate bird passed into a truly pitiable condition of extreme marasmus. Appetite, however, was usually preserved nearly to the end of life. Death may occur quietly or be preceded by convulsions.

Temperature curves

It was noticed that the illness associated with the presence of these bodies differed from spirochætal fever. It was non-febrile, indeed the temperature might be slightly sub-normal, and usually fell several degrees before death (*see* Chart, which is that of a hen with a very severe infection which terminated fatally).

Conditions influencing recovery

Recovery, if the infection was not too severe, seemed to depend largely on the care taken of the birds. If these were well fed and well housed, it often occurred that, while in the market, the vendors, who readily recognised the condition if there were any symptoms at all, cast the fowls out of the coops, letting them fend for themselves—a sentence of death in most cases. Post mortem, there is no gross lesion of any kind visible, and nothing is seen to account for death beyond the great emaciation.

Staining of endoglobular forms

Blood condition. Stained films.—It is convenient in the first instance to consider the appearance presented by a stained film. The Leishman and the Giemsa stain, or Borrel blue and eosin, all answer well as tinctorial agents, and the blood may be stained as for the malarial parasite. It was found to be a mistake to stain for more than ten minutes, as this tended to obscure such structure as the bodies possess. On the whole, perhaps, the last-mentioned method shows the structure of the bodies best, and it specially emphasises what is undoubtedly the chromatin which they possess. A glance at Plate VI., fig. 1, will reveal the fact that the bodies are situated in the extra-nuclear portion of the red blood corpuscles. I have never seen a free form, living or stained, though several times I have been nearly deceived, and almost imagined that such existed. The bodies may be close to the nucleus, so close as to touch it, or they may be quite at the rim of the corpuscle, or occupy a half-way position. There may be only one of them in a corpuscle—this is frequently the case—or there may be as many as seven. In such a case the bodies are usually small, and arranged close together. Two, three, or four are commonly present. In these multiple cases the bodies may be near each other or widely separated. They are very protean in form, and less so in size. Fig. 8, A shows a diagrammatic drawing of a bird's red corpuscle in which I have placed the commonest shapes met with in the peripheral blood. Those at the top and bottom of the corpuscle are undoubtedly the most frequently encountered. In a few cases I have seen a body lying close to the edge of the corpuscle, and apparently associated with a gap in the corpuscular envelope. This appearance is, however, distinctly rare, but added to the difficulty of diagnosis. As regards size, the smallest stained bodies, usually ring- or flame-shaped, measure about 1·5 micron.; the largest, which are often found in the lungs, are frequently 3·5 μ in their greatest diameter. A few measure as much as 4 μ. It will be seen that we have "coccoid" or solid spherical forms, "ring" forms enclosing a vacuoloid space, similar "ring" forms which look as though a membrane stretched half-way or wholly across them, "ring" forms with central dark-staining portions, signet-ring shapes, flame-shaped forms closely resembling some of the piroplasmata of mammals, irregular forms, somewhat star-shaped forms with dots round their periphery and granules in their interior, tiny crosses and granular broken-up forms suggesting *à priori* a sporing condition.

Description of endoglobular forms

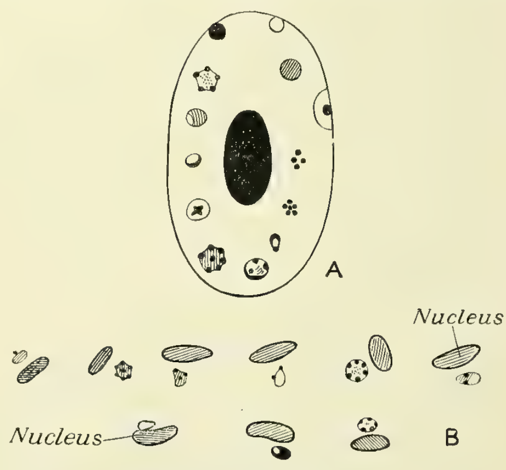


Fig. 8. A.—Composite drawing showing forms assumed by endoglobular spirochætes.
B.—Ditto in dehæmoglobinized film.
Leishman stain

A typical case

Plate VI., fig. 2, is a representation of the peripheral blood of the hen whose temperature chart is given. On admission, this bird was extremely ill, and its peripheral blood contained a large number of these bodies. It smelt foully and exhibited tremors and marked anæmia. It was put in a comfortable cage, given bedding and plenty of food and water. As a result, it improved for a time, and, though it was not easy to be certain on this point, I believe the bodies diminished in number while this improvement was maintained. At least this was the impression derived from a daily examination of the peripheral blood. There can be no doubt that towards the end of life a marked increase in the number of bodies took place, and this was associated with the remarkable fall in temperature already recorded. The bodies were for the most part spherical and of the "ring" form, but at different times all those presented in Fig. 8 were to be seen. Towards the end of the illness there were appearances suggesting a breaking up of the spherical bodies into tiny "spores," and a discharge of these granules from the corpuscles. It has to be noted that these bodies do not, as a rule, take on what may be termed the classical staining so characteristic of hæmatozoa, coloured by one of the Romanowsky methods. The typical blue colour seen in *Babesia* and the malarial parasite is rarely presented, though I have seen something approaching it in the case of piroplasma-like forms. The staining reaction rather resembles that of the corpuscular nuclei, though it is not quite the same, and in many cases, as indicated, there are appearances which suggest the presence of chromatin occurring either as a single dot at the pointed end of a flame-shaped form or as a series of dots arranged, usually at fairly definite intervals, round a spherical or heptagon-shaped body; or sometimes, but rarely, scattered irregularly about a spherical form, the majority being ranged round its periphery. By artificial light these dots show the true chromatin-red colour. In addition to the chromatin dots there are masses and streaks of the same material, for the most part occurring at the periphery of the spherical forms or at the rounded and thicker end of the tiny flame-shaped forms. Now and then the whole appearance was not at all unlike that presented by some of the smaller piroplasmata. The infected red corpuscles do not as a rule present any abnormal appearance, but some degree of polychromatophilia is common in the blood.

Morphology

On employing Ruge's[1] modification of Ross's method for malarial parasites, and thereby dissolving out the hæmoglobin from the corpuscles, the bodies can be seen lying near the nuclei, and it is noticeable in many cases that they have taken on the stain much more intensely than the nuclei. Their shape and general appearance is well shown by this method (Fig. 8, B), a fact which was regarded as tending to show that they were true blood parasites. Indeed, so far as colour went, they resembled the hue taken on by the central core of spirochætes. That these bodies are really situated within the substance of the corpuscles there can be no doubt. Careful focussing shows them, at least as a rule, not to be epicorpuscular, and this is also seen to be the case when the fresh blood is examined.

Endoglobular bodies in the fresh blood

Fresh films.—On making a good film of the blood these bodies are readily recognised if a little care is taken in discriminating them from free leucocyte granules, some of those forms mentioned by Nuttall and Graham-Smith[2] in their latest paper on Canine Piroplasmosis and certain blood appearances classed under the term hæmiconia. Some experience, however, in this class of work is essential. In freshly shed blood the bodies are invariably of a spherical form, and look not unlike young malarial parasites. Each body appears of a lighter colour than the corpuscle containing it, has a well-defined margin, and presents a faintly granular aspect. It focusses with the corpuscle, and is apparently embedded in the extranuclear substance of the latter. There is absolutely no sign of pigment. For a long time I looked in vain for true motility, both at room temperature and when using either a warm stage or a Nuttall's thermostat at 108° F. The nearest approach to it was a slight and almost imperceptible vibration. Recently, however, I saw an undoubted "body" move slowly and steadily almost completely round its corpuscle, and then come to rest close to the point

Motility

[1] Ruge, R. (March 19th, 1903), "Für Erleichterung der Mikroskopischen Malaria-Diagnose." *Deut. Med. Woch.*, Vol. XXIX.

[2] Nuttall, G. H. F., and Graham-Smith, G. S. (October, 1906), "Canine Piroplasmosis." *Journal of Hygiene*, Vol. VI., pp. 586–650.

whence it started. There was no possibility of error in this observation, which was made on a blood film kept at 108° F. in the microscope thermostat. These intra-corpuscular bodies are very resistant. Thus I have kept a fresh film for three days at room temperature and yet been able to demonstrate them. In some cases, indeed, the hæmoglobin had oozed out of the corpuscles, but the spherical bodies still remained *in situ* apparently unchanged. As a rule, however, when the blood is kept the bodies become more granular and also appear to increase in size. I have seen a condition result suggesting a breaking down and disintegration into granules. The appearance of free spherical forms attempting to gain an entry into corpuscles described by me[1] in an earlier paper was probably an error in observation, for, as stated, the presence of hæmiconia is very apt to deceive one.

The blood of infected birds taken at night failed to reveal anything new. Attempts were made to crush the corpuscles, but in the absence of a porcelain ball-mill this is a very difficult thing to do, and has been void of any useful results. As in the stained blood, so in the fresh, there is no evidence of the infected corpuscle having undergone change. A common measurement for the unstained bodies is $2 \cdot 8 \mu$ in either diameter.

Post mortem appearances

Post mortem.—Smears from the heart's blood, liver, spleen, lungs, kidneys and bone-marrow, show the bodies to be present in the red cells usually much in the same numbers as in the peripheral blood. The appearances presented by them are also, as a rule, similar to those described, save that in the lung smears, gaps or vacuoles may be seen in the red cells, which look as though they had been occupied by the bodies, and that these latter had, so to speak, fallen out of them or been discharged from them. If so, it is probably in the form of granules, for the disintegrated, granular forms are sometimes seen in considerable numbers in lung smears. The significance of this observation will be discussed anon. Furthermore, in the bone-marrow smears there has been seen a condition suggestive of absorption of some of the bodies by the large phagocyte mononuclears.

Feeding experiments with ticks, bed-bugs, and lice

At an early period it seemed as though this condition, like spirochætosis, was associated with tick infestation. Accordingly, gorged female ticks and larval ticks taken from birds with severe infection were dissected according to Christophers' method, and smears made of the gorged diverticula, the ovaries, eggs and other portions of the internal anatomy. In several cases unaltered bird's red corpuscles were found showing the bodies either unchanged or in the granular, "spore"-like or disintegrated forms sometimes met with in the peripheral blood. No other forms were found, and the smears made from the eggs and ovaries yielded negative results. Bed-bugs (*Cimex macrocephalus*) were also fed on the infected fowls, and smears from their alimentary tracts showed similar appearances to those presented by the ticks. The examination of lice (*Menopon* sp. ?) proved negative.

Attempts to transfer these bodies from the sick to the healthy fowl by means of ticks failed.

Nature of the Condition Discussed.—At first, and indeed for a long time, I was unable to come to any definite conclusion regarding these bodies. It was evident that they were blood parasites of some sort, for, after careful consideration, I was able to assure myself that they did not represent any degenerative condition of the corpuscles associated with vacuolation or extrusion of nuclear substance, and also that they were not of the nature of Cropper's bodies, which, for one thing, can only be stained with difficulty.

The appearance in the fresh blood, the results obtained by the modified Ross' method of staining and the general arrangement of the stained parasites in the corpuscles, together with their association with a definite illness, all convinced me that I was dealing with some form of pathogenetic blood parasite. I asked myself if the condition could be post-spirillary,

[1] Balfour, A. (May 1st, 1907), "A Peculiar Blood Condition, probably Parasitic, in Sudanese Fowls." *Journal of Tropical Medicine and Hygiene.*

but at that time thought that any such state must be of the nature of a corpuscular degeneration. I knew that coccoid bodies had been found in the blood after relapsing fever in man, and I also knew that these were stated to occur free in the plasma.

At the early stage of the work I was not aware of von Prowazek's observations on the invasion of the red corpuscles by *Sp. gallinarum*, and indeed it was not until I had worked out the problem that I became acquainted with his researches. At this time also Breinl's [1] work on intra-corpuscular forms of *Sp. duttoni* had not been published, and for a time I went astray and was inclined to think that I had found a peculiar form of piroplasmosis in the fowl. There were many facts to favour such a view, but I was never perfectly satisfied with its correctness, for, morphologically, many of the bodies would not answer to any known form of piroplasm and I could find no developmental stages in the ticks.

Cultural experiments

Blood was collected, together with sterile citrate solution, in sterile glass tubes which were sealed and kept either at 37° C. or at laboratory temperature. The bodies either remained unchanged, and could easily be recognised after the lapse of three days, or they underwent the same change as in the ticks and bed-bugs, breaking up into small deeply-staining dots, which formed something like irregular and tiny rosettes. When bacterial contamination occurred the bodies speedily disappeared.

Inoculation experiments

I had recourse to inoculation experiments. These sometimes failed, sometimes succeeded. In the former case I thought that I must have employed immune birds, but the fact that I was able to reproduce the condition in some of the inoculated birds helped to keep me from getting at the truth. Failure attended inoculation of gerbils and of a toad (*Bufo regularis*); I applied for assistance to several authorities, but without success. The condition seemed to puzzle everyone. Professor Laveran, from a study of stained preparations, suggested that it might be a coccal invasion analogous to the bacillary invasion of the erythrocytes of frogs (*Rana esculenta*) first described by Kruse, and then by himself.[2] A study of the drawings of this condition showed a certain similarity, but I was unable to subscribe to this hypothesis.

The correct conclusion

On returning from leave in 1907, I set myself to solve the problem, and as I was approaching the solution Dr. Sambon decided the matter by declaring that these bodies, specimens of which I had given him, were really intra-corpuscular forms of the spirochæte. I had come to the same conclusion, especially since I had seen the papers of Breinl [3] and von Prowazek, but it was Sambon's announcement which served to confirm my opinion and dispel my doubts. It is only strange that I should not have recognised this at an earlier date, but I now know that my failure was due to insufficient staining of the blood for spirochætes, to press of other work which prevented me working steadily at the subject and weighing the evidence I had collected, and also, in part, to lack of necessary intuition.

Moreover, although I [4] considered the question of any association of the condition with spirochætosis, I was rather led astray by the following experiment in December, 1906.

A hen, seemingly recovered from spirochætosis, and apparently with no parasites in its blood, was put in a cage which contained a fowl suffering from the condition which has just been described. It was liable to be attacked by ticks and their progeny, and, indeed, ticks were fed on it in connection with work on spirochætosis. About eight days after its recovery (?) from the latter I was surprised to find for the first time many of these curious intra-corpuscular

[1] Breinl, A. (November 9th, 1907), "On the Morphology and Life-History of *Spirochæta duttoni*." *Annals of Tropical Medicine and Parasitology*, Series T.M., Vol. I., No. 3.

[2] Laveran, A (May 13th, 1899), *C. R. de la Soc. de Biol.*

[3] *Loc. cit.*

[4] Balfour, A. (November 9th, 1907), "A Peculiar Blood Condition, probably Parasitic, in the Blood of Sudanese Fowls." *Journal of Tropical Medicine and Hygiene.*

bodies in the blood. It again became sick and drowsy, and harboured these bodies for a month. They gradually lessened in numbers, however, and eventually entirely disappeared, the bird recovering completely. Naturally, perhaps, I regarded this as proof that fowl No. 1 had been infected from fowl No. 2, and that the ticks had transmitted the disease. The result of this experiment coloured my views of the condition for a long time, and it never occurred to me that in fowl No. 2 I was working with a bird which was already in the same condition as that into which fowl No. 1 fell, *i.e.* a bird which had previously suffered from spirochætosis and had passed into what I now term the "after phase" of that condition. Doubtless had I stained the blood of fowl No. 1 for a sufficient time I would have found a few spirochætes in it, and I might have witnessed them co-existing with the bodies. Possibly I did not examine the fresh blood with sufficient frequency, and altogether this case points a useful lesson in blood work in the Tropics, and reveals its pitfalls and the danger of drawing any conclusion from a single experiment, however definite its results may appear.

The following observations were those which led me to what I believe is a correct conclusion, and which coincides with Dr. Sambon's opinion :—

1. I noticed that fowls which recovered from spirochætosis, very often after the lapse of a few days, exhibited these bodies in their bloods.
2. I found that the spirochætes either did not wholly disappear from the peripheral blood at the crisis or, if they did so, that they reappeared, and synchronously with their reappearance that these bodies showed themselves in the corpuscles.
3. It was noticeable that no fowl with these bodies in its blood could be inoculated with spirochætosis.
4. The disease associated with the presence of these bodies in the blood presented symptoms closely resembling those of spirochætosis, and which might quite well be due to a sub-acute or chronic form of the disease.
5. There were no characteristic post mortem appearances.
6. The general blood condition closely resembled that found in spirochætosis.
7. The morphology and staining reactions of the bodies could perfectly well be explained on the hypothesis that they were spirochætes which had entered the corpuscles, had coiled up in them or become encysted in them, had broken down or contracted, and eventually had become broken up into granules. The gap sometimes seen in the corpuscular envelope could also be explained on this basis.
8. The morphology and staining reactions could not be satisfactorily explained on any other hypothesis. The bodies did not exactly resemble piroplasmata, were unlikely to be a new form of hæmatozoon, did not seem to be of a bacterial nature as evidenced by examination of the fresh blood, were certainly not due to degeneration or vacuolation, and bore no resemblance to Cropper's bodies.
9. It was found that von Prowazek had described a somewhat similar condition resulting from the invasion of the red corpuscles of fowls by *Sp. gallinarum*, while during the course of the investigation Breinl[1] described an endoglobular stage of *Sp. duttoni* in the rat, and Lingard recorded the fact that he had seen spirochætes enter erythrocytes.
10. Recently I discovered in geese a condition precisely similar to that obtaining in fowls—*i.e.* a spirochætosis followed by the appearance of the intra-corpuscular bodies, the symptoms of the associated disease closely simulating those seen in fowls (*vide infra*).

[1] Breinl, A. (November 9th, 1907), "On the Morphology and Life-History of *Spirochæta duttoni.*" *Annals of Tropical Medicine and Parasitology*, Series T.M., Vol. I., No. 3.

11. Eventually I[1] witnessed under the microscope in a few cases the entry of spirochætes into red blood corpuscles, and in one instance the formation of a body very closely, though not exactly, resembling those described in the fresh blood of infected birds.

I think, therefore, the chain of evidence is now complete, and before going on to describe one or two cases in detail and to discuss some aspects of the condition and refer to its treatment, it may be interesting to refer briefly to the work of the above-mentioned authors.

Lingard's work

Taking Lingard first, apart from the observation above noted, he described and figured[2] certain "protozoic" forms in the blood of cattle in India, which I think might possibly be explained on the supposition that they are endoglobular forms of the spirochætes discovered by Lingard himself in Indian bovines.

A frog parasite

Moreover, in this connection one would note that the so-called cytamœba of the frog, observed by the Liverpool observers[3] in West Africa, is exceedingly like some of the bodies in fowls' corpuscles. I should think it is quite possible that it may really represent an endoglobular stage of a spirochæte.

Breinl and *Sp. duttoni*

Breinl described and figured *Sp. duttoni* lying in the substance of the red corpuscles, but the appearance is totally unlike anything met with in fowls, the parasite being in the form of a looped spiral thread or skein, and apparently not undergoing any contraction or encystation. At the same time Breinl noted that in the spleen and liver the spirochætes formed skeins which became encysted forms that broke up into small red granules (*vide* Review Supplement, "Spirochætosis," *page* 191).

Observations of von Prowazek

Prowazek's paper is, however, the most important. He first saw the entry of the spirochætes into the red blood corpuscles in a test-tube experiment where very diluted inactive serum was added to spirochæte material which had been washed and centrifuged twice, and therefore contained little complement. Under such conditions it was easy to observe that the parasites actually migrated into the red corpuscles, as in some cases the corpuscles had died and were "thrown" to and fro by the very mobile spirochætes. In some cases the parasite transformed the erythrocyte into the shape of a pear. Later, this stage was recognised in cover-slip preparations or in hanging drop, and to a less extent in quickly dried films. It was noted that the spirochætes entered the corpuscles, singly or two together or, but seldom, in threes, and moved in the corpuscles in a circle in a very lively manner, quite different to that exhibited by the parasites in the free serum.

Prowazek was inclined to regard this behaviour as the formation of a special resting stage, but noted that nothing definite could be determined until it had been studied in the tick. The spirochætes were observed to migrate into old as well as into the young corpuscles, which are more oval and have various kinds of granules in them. In some instances the parasites were also seen to leave the corpuscles they had entered. All these appearances are well illustrated. This cell parasitism, like that met with in *Treponema* and *Sp. anodontæ*, tended to confirm Prowazek in his view that *Sp. gallinarum* was a protozöon and not one of the bacteria; but we must not lose sight of Kruse's observations on bacillary invasion already cited.

In this paper also Prowazek enters very fully into the morphology of *Sp. gallinarum*, specially mentioning the apparent conjugation of thin and broad forms, or of the spherical masses of protoplasm which may be formed upon the spirochætes. When on two different

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[1] Balfour, A. (February 1st, 1908), "Spirochætosis in Sudanese Fowls." *Journal of Tropical Medicine and Hygiene.*

[2] Lingard, A. (July, 1907), "Some Forms of Spirochætosis met with in Animals in India." *Journal of Tropical Veterinary Science*, Vol. II., No. 3.

[3] *Annals of Tropical Medicine and Parasitology* (December 9th, 1907), Series T.M., Vol. I., No. 3.

parasites these may unite and mingle, and suggest resting stages prior to peculiar sexual processes. All this, however, requires confirmation, and need not be further discussed at present. Personally, save in one instance (Fowl I., *vide infra*), I have not seen these protoplasmic balls in the case of the Sudan spirochæte.

A comparison

I have studied Prowazek's paper and diagrams closely, and have come to the conclusion :—

1. That in the Sudan spirochæte, cell-parasitism is much more frequent than in the case of the *Sp. gallinarum* strain with which he worked. Indeed, it appeared to be the rule rather than the exception, and, if carefully looked for, will be found in nearly every case which recovers from the acute disease.
2. The cell infection is often much more severe in the case of the Sudan spirochæte, and multiple invasion is common. A glance at Plate VI., fig. 1, will confirm this statement. At the same time I will not go so far as to say that each of the bodies in the corpuscle represents a spirochæte, which, let us say, has passed into a resting stage. In the fresh blood I have seen appearances which suggest that the spirochæte may undergo transverse division at several points within the corpuscle, and that each segment then contracts and encysts, forming the smaller class of the endoglobular bodies. Apart from what has been seen this would explain some of the peculiar appearances and the great difference in size and shape which exists between the bodies. In some cases they are produced by a complete parasite, which has become coiled up, and the central core of which has degenerated; in others they represent fragments of a spirochæte which has divided into several parts, each part tending to contract and possibly encyst. May not this also explain the reason for the apparent breaks or gaps seen in stained specimens of the spirochæte, these being the points at which the intra-corpuscular fission takes place?

Possible intra-corpuscular fission

Exit from corpuscles never witnessed

3. It is possible that the spirochætes may leave the corpuscles, but I have never seen this occur. I have, however, witnessed one of the spherical bodies bulging out the envelope of the corpuscle as though it were endeavouring to get free.

One has to ask, Is this a new species of spirochæte? Does its life-history entitle it to be classed separately from *Sp. gallinarum*? Before dealing with this aspect of the subject, about which little can in any case be said, it will be well to record more fully some of the cases observed.

In the first place we take a fowl (Hen 20), the temperature chart of which has been given (*page* 47). This was a bird which came in when in the "after phase," and the following are the notes upon its condition and subsequent history :—

Illustrative cases

CASE I. *January* 19*th*, 1907. White and speckled fowl brought in from the market, Khartoum. Very ill and extremely emaciated. Masses of the larvæ of *Argas persicus* adhering to the bare patches of skin under its wings; smelt foully; was anæmic and suffering from tremors of the body. The blood showed that there was very heavy infection of the red cells, often multiple. The fresh blood was preserved for several days between slide and cover glass, but nothing special was noted.

In this case also, as in others, wet films were fixed by osmic acid or in Flemming's fixative; but these measures produced no change in the appearance of the bodies, and failed to yield any fresh information.

January 20*th*. A considerable quantity of citrated blood inoculated subcutaneously into Fowl 21 with negative results. Either Fowl 21 was immune, or the blood is not infective in the "after phase" when no free spirochætes are present in it. As mentioned, however, inoculation has several times proved successful during the "after phase," but I am inclined to think that in these cases undetected free spirochætes must have been present in the blood used for inoculation, as well as the endoglobular forms. The point is a little difficult to decide, owing to the presence of so many immune birds, and this difficulty could only be obviated by rearing a special lot of chickens and employing them in the work. I hope to carry out investigations in this direction.

January 21st. Bird distinctly stronger and improved in condition, no doubt owing to care and good feeding ; but, on

January 25th an enormous infection was present, and in many corpuscles as many as five, six, or seven bodies were present. As indicated, this may not represent invasion by a corresponding number of spirochætes.

After this the infection seemed to diminish in severity, no doubt because some of the incorporated spirochætes had broken down and been discharged as tiny granules from the corpuscles. The blood was examined every day till

February 7th, when a distinct increase in the number of bodies was apparent.

February 9th. A great infection was visible. The bird was somnolent and prostrate. Death occurred, preceded by a marked fall of temperature and convulsions.

Post mortem.—There was no gross lesion of any kind visible. Neither spleen nor liver was enlarged. There was some congestion of the renal vessels, and the kidneys had a mottled appearance.

Smears were made from the heart's blood, lungs, liver, spleen, kidneys, cerebro-spinal fluid and bone-marrow. The last named was dark red and fluid. In all, the bodies were present in the red cells. The lung smears were the most interesting. In these many corpuscles were seen in which the extra-nuclear cytoplasm had apparently vanished, but where large, irregular forms of the bodies still remained, doubtless retained by an unstained envelope from which the hæmoglobin had escaped. The substance of the bodies was broken up into little rods and dots which took on the chromatin stain. Some of these bodies were 4 μ in either diameter.

In this case and in two others I was able to study sections of the spleen, lung, liver and kidney. The tissues were fixed in perchloride of mercury and alcohol, embedded in paraffin, and stained with Leishman and eosin-hæmatoxylin. Beyond what appeared to be a kind of chronic venous congestion, I could detect nothing abnormal, save, perhaps, in the liver of Hen 20, where there was a marked leucocyte infiltration round the periphery of the lobules and extending into them between the cells.

I compared these sections with those prepared from the organs of a healthy fowl.

The next cases are of greater interest because the condition was followed through from the acute stage to the "after phase," and some interesting inoculation experiments were performed.

Case II.—*Fowl* I.—*December 22nd,* 1907. Admitted suffering from spirochætosis. Infection severe and bird distinctly ill.

December 23rd. Spirochætes numerous. Blood, about 5 c.c. in each case, taken from wing vein and inoculated into—

(*a*) Fowl 33, which showed a large number of intra-corpuscular forms ;

(*b*) Fowl J, which showed intra-corpuscular forms in very small numbers.

N.B.—In neither case was the inoculation successful.

December 26th. The crisis had occurred, and all the spirochætes had vanished from the blood. About 5 c.c. were inoculated into—

(i) Fowl K, a healthy young bird.

N.B. - Result negative.

From *December 25th* to *December 29th,* the bird improved in health, and the examination of its peripheral blood was uniformly negative, both as regards free spirochætes and endo-globular forms. The blood was not again examined till *January 1st*, 1908, when spirochætes were again found present in considerable numbers, and a few endo-globular forms were also found.

January 2nd. Condition much the same, but the number of intra-corpuscular forms had increased. In fresh films a curious appearance was seen as if stationary but "rippling" parasites had surrounded a colourless nucleated cell (probably an erythrocyte, which had lost its hæmoglobin), and had formed a kind of girdle round it. No further change was noticed though the blood was under observation for a long time. In blood examined microscopically in a Nuttall's thermostat a spirochæte was distinctly seen to penetrate into a red cell, and to break up into four colourless, motionless short rods. No further change was noticed until the whole corpuscle shrunk and disintegrated. In blood kept sealed up under the cover glass for some time, and then smeared and stained, the appearances shown in Plate VI., fig. 2, were exhibited. In one corpuscle a large form is seen enclosing in its loop, portions of the extra-nuclear portion of the red cell, which is evidently becoming vacuolated. Prior to this I had thought these large forms were late stages in the history of what I fancied was a special parasite, but this indicated to me that the appearance was really due to the incorporated spirochæte, soon after its entry, having formed a loop before contracting and producing vacuolation of the red cell.

In another corpuscle a spirochæte is seen attached at one end to what is either a solid spherical body or one of the protoplasmic balls described by Prowazek.

About 5 c.c. of blood again inoculated subcutaneously into

(ii) Fowl K, which had remained quite healthy and with normal blood.

N.B.—Fowl K was found to be infected on *December 4th*, when it showed a small number of spirochætes in its blood, and eventually passed into the "after phase." Its history will be detailed.

On this date (*January 2nd*) it was also noted that many of the spirochætes in the blood of Fowl I. were applied end to end. No clumps were seen.

December 2nd. All the free spirochætes had again vanished and the number of intra-corpuscular forms had increased.

By *December 5th*, the number of bodies had greatly increased, and by *December 6th*, appearances suggesting multiple infection were common. All this time, even after prolonged staining, and repeated and prolonged examination, no spirochætes could be found, nor did they ever reappear in the peripheral blood.

December 8th. On this day an enormous increase of the bodies was found. The bird was worse, and one eye had become inflamed, a condition which resulted in perforating ulcer of the cornea.

After this the history is one of progressive anæmia and weakness without much change in the blood condition, until the bird died on *January 15th*, 1908, twenty-five days after being admitted with spirochætosis, and fifteen days after the commencement of the "after phase" *i.e.* the finding of intra-corpuscular spirochætes.

Smears were made from the lung, liver, spleen, and bone-marrow. The lung smears alone presented anything of special note, and here it was quite evident that the bodies had in many instances been discharged from the corpuscles, leaving large vacuoles in them. That this was the case was further evidenced by the large number of bodies broken up into granules. The appearance was that of a vacuole, with its edge staining a deep purple colour and its interior, if one can speak of the interior of a vacuole, being partly filled with the granular debris of the central core of the parasite. What may have been free granules were also seen in the smears. Portions of the organs were prepared and kept embedded in paraffin, but these were most unfortunately all lost in the fire on May 11th.

Case III.—Fowl K. Young healthy bird.

December 26th. Inoculated, as noted, with negative results, with post-critical blood of Fowl I.

January 1st, 1908. Again inoculated with blood of Fowl I. containing spirochætes both free and intra-corpuscular.

January 4th. Found infected with free forms of spirochæte only.

January 5th. No free spirochætes could be found, but in one film two undoubted intra-corpuscular forms were found. Bird seemed well. Weight, 940 grams. Temperature, 107·7° F.

January 7th. Neither form of spirochæte found to-day, despite a long search and heavy staining.

January 8th. Temperature 108·6° F. Very interesting specimens. In the fresh blood, at room temperature, a spirochæte was seen to enter a corpuscle, but the formation of the intra-corpuscular form was not observed.

In fresh blood, kept in the thermostat at the fowl's temperature, a spirochæte was distinctly seen coiled up at one end of a corpuscle and evidently in the process of forming one of the endo-globular bodies. The spirochætes had therefore recurred.

A well marked ribbon form, with chromatin dots, a break in the middle and filiform extremities was seen. There were numerous "tangles" in which the chromatin dots in the central cores were very evident.

January 9th. The appearances were the same. 5 c.c. of citrated blood were inoculated into

(*a*) Fowl L, which appeared to be healthy.

On *January 11th* this bird showed a few intra-corpuscular forms, but as it had never shown spirochætes it is probable that the bird had not been a clean one, *i.e.* had been recovering from a spirochæte infection, and that the bodies had been missed. This shows one of the difficulties attending the work in a place where, though the disease is common, the infection may be very slight, especially towards recovery from the "after phase."

Fowl K never became very ill. It had the disease in a mild form, though it presented a good many intra-corpuscular forms in its blood. Nothing of special note was observed till

January 18th, when a great diminution in the number of the bodies was found. This continued. On

January 26th, scarcely any could be found. Weight 820 grams. By

March 22nd, the bird had become strong and well, and weighed 995 grams. On

April 15th, it was again inoculated with the blood of a fowl suffering from severe acute spirochætosis, but it proved immune, although on one occasion—on April 20th—a single intra-corpuscular form was noticed.

Treatment of "after phase"

As it is far more common to get birds in the "after phase" than when they have spirochætes in the blood, and as the latter condition can, as mentioned, be readily prevented and cured, experiments were begun to find if the exhibition of 'Orsudan' could save birds suffering from a severe "after phase." Unfortunately the work, which had not advanced very far, was interrupted by the fire, and there is no use detailing the few cases treated. One point only may be mentioned, that the 'Orsudan' seemed to stimulate the leucocytes to phagocytic action, for what seemed to be intra-corpuscular forms were found in the mononuclears.

The disease in geese

Mention has been made of a similar condition in geese. I believe it is due to the same spirochæte. At least the disease runs a similar course, though in goslings tender feet and paresis or paralysis of the legs is a marked symptom. We know that geese can be infected with *Sp. gallinarum*, and the fact that geese, after showing free spirochætes in the blood, exhibited the same intra-corpuscular bodies as the fowls, helped me to the ultimate diagnosis. One is inclined to doubt the existence of a special *Sp. anserina*, and it is worth noting that in a gosling dead of the disease I found in the spleen a caseous nodule similar to the caseous yellow granulations described in the livers of geese which have succumbed to the attack of *Sp. anserina*.

There is probably one special avian spirochæte for domestic birds at least, which was first named *Sp. gallinarum*. I do not think I can claim to have found a new species in the Sudan spirochæte, solely on account of its great tendency to cell-parasitism. This is certainly much more marked than in Prowazek's cases, but may perhaps be explained by the different breed of fowls or the different climatic conditions. It may have something to do with changes undergone in the tick.[1]

Nature of "after phase"

I regard this "after phase" as a definite stage in the life-history of the parasite. As Prowazek says, it may be a true resting stage, and I am inclined to think that it provides for re-infection. The tiny granules into which the intra-corpuscular forms break up may possibly be of a "spore" nature, and play a part in the lung, where, as noted, they are most commonly found.

Breinl's hypothesis mentioned in the Review Supplement (*page* 191) is interesting in this connection, but at present little definite can be said, and owing to the minute size of the granules it will be a matter of extreme difficulty to find out what becomes of them. I had hoped by an examination of sections to determine something regarding them, but the tissues were lost. After the fire, however, the tissues of one fowl with a small intra-corpuscular infection were secured, and Dr. Wenyon kindly examined them for me at the London School, fixing and staining in block by Levaditi's method.[2] The sections, unfortunately, yielded no information.

As regards the season of the year when spirochætosis is most common, I can give no opinion. It seems to occur all the year round. At any time almost, birds in the "after phase" can be found in the market at Khartoum, but it is not easy to pick up a bird with the free forms in its blood, or one with a large infection at the intra-corpuscular stage. That the condition is one of great importance there can be no doubt, in a country where there is a large trade in fowls, and where these birds and their eggs form specially valuable articles of diet, as, indeed, is the case in most tropical countries. There is no evidence of any human disease being associated with the condition in fowls.

I am indebted to Dr. Beam for the excellent photographs of the sick birds, and to Dr. Wenyon and Captain Olver for kindly discussing the matter with me. Professor Laveran and others also were good enough to take an interest in the subject, while, as stated, Dr. Sambon recognised the true nature of the condition before I had got together all my proofs, and while I was still in some doubt as to its precise significance.

Routine Work

The following is a list of the various examinations conducted in the bacteriological laboratory since the last list was compiled for the Second Report. All entomological examinations and reports on plant diseases have been performed by Mr. King and are not included.

The period of work covered is twenty months :—

(*a*)	Morbid secretions and exertions	28
(*b*)	Blood	253
(*c*)	Bacteriological apart from (*a*)	48

[1] A recent paper in the *Journal of Tropical Medicine and Hygiene* (August 1st, 1908), mentions the discovery of fowl spirochætosis by Galli-Valerio in Tunis, and suggests that the North African disease is distinct from that met with in Brazil and is due to a different species of spirochæte. Galli-Valerio believes the Tunisian spirochætosis to be the same as that found in the Anglo-Egyptian Sudan.

[2] Levaditi, C (October–November, 1906), "Les Nouvelles Recherches sur l'Étiologie et la Pathologie experimentale de la Syphilis." *Folia hæmatologica*, Nos. 10 and 11.

(*d*)	Parasites apart from (*a*) and (*b*)	19
(*e*)	New growths	16
(*f*)	Other pathological conditions	26
(*g*)	Medico-legal	2

Space does not permit of any detailed reference to the various conditions encountered, and in any case only a few were of special interest, and these for the most part have received notice in the Review Supplement.

Miscellaneous Notes

Halteridia

Captain P. E. Vaughan has again been good enough to send blood slides from various species of animal in the Bahr-El-Ghazal Province. Halteridia have been found in the bloods of the following birds which have been kindly identified for me by Mr. A. L. Butler from skins or descriptions sent him by Captain Vaughan :—

Serinus Icterus (Bonn et Vieill.). Common yellow-fronted Serin.

Neophron Monachus (Teuun). Brown Scavenger Vulture.

Trachyphonus Arnaudi (Des Murs). Arnaud's Spotted Barbet (very probably).

Hirundo Æthiopica (Blauf). Abyssinian Swallow (probably).

Bubo Cinerascenus (Guérin). Grey Eagle Owl.

Merops Nubicus (Gur.). Nubian Bee-eater.

Turtur Auritus. Turtle Dove.

Trypanosomes and big game

A large number of blood smears from different kinds of mammals, both herbivora and carnivora, such as the elephant, buffalo, many kinds of antelope, wart-hog, etc., have been examined, but in none of them were any parasites or any pathological conditions found. This is somewhat remarkable, as the majority come from a trypanosomiasis region haunted by tsetse flies. As regards the antelopes it may be, as Captain Olver thinks, that though trypanosomes are not to be found in the peripheral blood, encysted or latent forms will be found in smears from the internal organs, notably the spleen and liver. This is a matter of considerable interest for, as is well known, the relationship of the large game of Africa to trypanosomiasis remains a somewhat vexed question, and on its determination important issues may depend.

Blood parasites of the common Khartoum toad

As regards reptiles, the blood of *Bufo regularis*, the common toad in Khartoum, was found to harbour in many cases both a trypanosome and a hæmogregarine. Both, I think, have been previously described, the former being *T. rotatorium* (Mayer). As regards the latter I have been unable to trace the reference, but a very similar form has been noticed in the Algerian toad.[1] The trypanosome in Khartoum toads has only been found in two of its forms, though three are known to exist in the blood of this toad, and, indeed, have been found by Wenyon in the Sudan. The third is a much longer form than those shown in Plate III., fig. 2, which is inserted to demonstrate the difference between reptilian and mammalian trypanosomes, and to contrast the hæmogregarine of the toad with those of snakes and lizards (*vide* Plate III., fig. 1). In the stained blood films of toad's blood, one has often found the corpuscular nucleus in infected erythrocytes curiously displaced, sometimes lying almost at right angles to the long axis of the cell, and consequently superimposed upon the contained parasite. This condition is, in all probability, caused by blood changes, induced by the method of preparation, but it seems worth noting as one has seen no reference to it elsewhere, and the appearance is sufficiently striking.

[1] There is a mention of what is probably the same parasite in the *Annals of Tropical Medicine and Parasitology* (November, 1907), Vol. I., No. 63.

Sanitary Notes. Khartoum

By the Director

Historical.—It is always instructive, as well as interesting, to trace the sanitary history of any town or locality, and this is especially the case in the Tropics, where, of late years, conditions have rapidly altered in many places owing to increase of knowledge and the recognition of the primary importance of proper and adequate sanitary measures.

In the Second Report of these Laboratories, the remarks of Schweinfurth, regarding the prevalence of malaria in old Khartoum, were quoted and commented upon. On this occasion one has gone further afield. Khartoum is not an ancient city, and in the past the literature dealing with it, save that of a military nature, has not been extensive. It would appear that the town itself was founded by Mohammed Ali, somewhere about 1830. No doubt prior to this date there had been habitations—fishermen's huts and such like—on the site later occupied by the town, but the latter may be said to date from about 1830, when a fortified camp was established on the land between the two Niles.

In 1839, the Governor, Khursed Pasha, taught the Khartoumers how to make and use bricks for building purposes and persuaded them to give up their huts of skin and reeds.[1]

By 1846, Khartoum had become a place of considerable importance. Petherick,[2] who visited it then for the first time, speaks of an agreeable stay which he made there in March, but notes the low-lying situation, the danger of inundations, and the consequent necessity for embankments. He also testifies to the irregular construction of the town, and the presence of narrow and tortuous streets. Otherwise he does not comment upon its sanitary or insanitary condition. At that time there were only five European residents, apart from the few Roman Catholic missionaries. In 1860, this number had increased to twenty-five.

Petherick mentions the rainy season, but adds that there are usually only two or three heavy falls of rain during the summer, and that the sandy soil soon absorbs the water.

Melly's visit, 1850

In 1850, George Melly,[3] an enterprising Liverpool man, and his family, penetrated as far as Khartoum. In the work edited by his son we read of the town possessing about 3000 houses and a population of 30,000. There was a large garrison—10,000 infantry and 2000 cavalry. There were no wide thoroughfares, though here and there a space resembling a square could be encountered.[4] The climate, it is noted, was pleasant in December, and it is interesting to learn that figs, bananas, pomegranates, and "cream fruit" were grown in the gardens together with grapes and oranges. How few of these are obtainable at the present time! The architecture of the houses was primitive, and the streets are stated to be quite impassable after rain in the summer season, so much so that "no one attempts to quit his dwelling during a rainfall."

Melly actually brought tinned salmon with him, supplied by Messrs. Fortnum and Mason, and produced it at a dinner with great success.

Sir Samuel Baker's first visit, 1862

Sir Samuel Baker,[5] however, is the first to give us some idea of Khartoum from a sanitary standpoint. He visited it in 1862, and describes it as a miserable, filthy, and unhealthy spot. The houses were chiefly built of unburnt brick, the town was densely crowded with a population of 30,000. It possessed neither drains nor cesspools, its streets were redolent with nuisances, and dead animals were allowed to lie about in them. On his return to Khartoum after his Nile voyage he found malignant typhus raging. Out of 4000 black troops, only 400 remained alive, and he again speaks with disgust of the filthy and crowded alleys.

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[1] Gleichen, Count (1905), "The Anglo-Egyptian Sudan."

[2] Petherick, J. (1846), "Egypt, the Sudan, and Central Africa."

[3] Melly, G. (1851), "Khartoum and the Blue and White Niles."

[4] Its wide streets, planted with trees, and fine open spaces constitute one of the features of modern Khartoum, thanks largely to the zeal and energy of its Governor, Colonel E. A. Stanton.

[5] Baker, Sir S. W. (1867), "Albert Nyanza."

Sir Samuel Baker's second visit, 1870

In 1870[1] he found the population had fallen to about 15,000, but otherwise the town remained unchanged. In October he speaks of it as a hateful spot. "Nothing," he says, "can exceed its misery at this season." He again alludes to the absence of drainage, the presence of mud, the dense population, probably in reference to crowded dwellings, for it had diminished one half, and above all to the "exaggerated stench." "These," he remarks, "have vanquished the European settlers." "No wonder!" we are inclined to say, and pause a moment to comment on the evil effects of the overcrowding.

Jennings[2] has recently written of the terribly insanitary conditions of the towns in Abyssinia at the present day, where "the inhabitants could not survive at all but for the merciful dealings of a tropical sunlight, which can well-nigh convert the smell of a pole-cat into the aroma of a nosegay."

Now the same, or even a mightier sun, is and was operative at Khartoum, and there can be no doubt that it was in some measure the overcrowding which led to such dire effects resulting from insanitary surroundings. Moreover, one must distinguish between sun plus dryness, and sun plus moisture, as will be seen when we come to deal with prevailing conditions.

Felkin's visit, 1880

Our next and last author is Felkin,[3] a medical man who was at old Khartoum in 1880, and remarks: "I noticed a great difference in Khartoum since my first visit eighteen months previously. The sanitary arrangements were in much better condition, but it is a great mistake that the town is built on its present site. As it lies on low ground at the junction of the Blue and White Niles, in the Kharif a great part is inundated; on the other side of the Blue Nile there is much higher ground, and the town if placed there would naturally have been more salubrious. In spite of these disadvantages it is rapidly improving, the grand Government buildings were nearly finished, many good houses and a large hospital are being built, while shops of a better class are already opened."

So much for the past, and the city which was swept out of existence by the Mahdi and the Khalifa.

Let us very briefly consider the sanitary problems presented by that new Khartoum which has arisen on the ruins of its predecessor, and has spread to that northern bank of the Blue Nile which Felkin quite correctly believed to be a better site for the capital. Khartoum is situated on latitude 15° 29′ North and is 1255 feet above the level of the Mediterranean, the figure for Khartoum North being 1269 feet.

Site

Site.—The main town, on the southern bank of the Blue Nile, is placed, according to Ward,[4] in a fine high and healthy situation, but in reality on a bed of alluvium, part of which is below Nile level at full flood, and the banks of which are exposed to the scouring action of the river, which annually eats into them and carries masses of soil down stream. As a result this southern bank has had to be protected by a huge wall of masonry. If the Blue Nile were ever to reach its highest known level it would surmount its southern bank, and in the absence of preventive measures would flood the central part of the town, which lies in a hollow. To the south of this depression the ground rises very considerably, and spreads away to the bare treeless and wind-swept desert, which, while contributing to the healthiness of the city, furnishes the sand that in the haboub season sweeps upon the town and envelops it in a black or yellow mantle of acute discomfort.

Khartoum North

On the northern side of the Blue Nile the banks are bold and high, and here Khartoum North has been placed, with its railway station, stores, barracks, and large native settlement.

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[1] Baker, Sir S. W. (1874), "Ismailia."

[2] Jennings, Captain (1906), "With the Abyssinians in Somaliland." *Journal of Tropical Medicine*, p. 62.

[3] Wilson, C. T., and Felkin, R. W. (1880), "Uganda and the Egyptian Sudan."

[4] Ward, J. (1905), "Our Sudan: its Pyramids and Progress."

A glance at the map, *page* 75, will explain the general situation for all practical purposes. There can be no doubt that Felkin's criticisms, from a sanitary standpoint, were fully justified, and his view as regards the new Khartoum is shared by many, including Sir Charles Watson, who served on General Gordon's staff.

There may, however, have been good and weighty reasons for rebuilding the town on its old site, and it must be confessed that Khartoum North is a dusty spot. Still, had the whole town been on the northern bank, the southern could have been cultivated freely, without much risk of mosquito invasion, the outlook would have been pleasant, on green gardens, palm groves and dura fields, while the problem of sanitation—especially as regards water supply and sewage disposal—would have been greatly simplified. Now one has to cater for two towns instead of one, and two towns separated by a wide and often rapidly-flowing river. This same river too would to some extent have mitigated the dust nuisance produced by the southern haboubs, for the stretch of water has often a remarkable effect in diverting or aborting the lesser sand-storms.

Geology of site

As regards the geology of the site, the alluvial deposit of clay and sand extends to a depth of about 70 feet, and is then replaced by a comparatively porous sandstone. Layers of this Nubian sandstone are found to a depth of some 300 feet, and in them occur beds of gravel, some of which are water-bearing. Strata of clay are said to seam the sandstone, but reliable evidence as to their presence is lacking. The surface soil for the most part consists of loose sand. Where this is absent or has been blown away by wind action, black-cotton soil is found, a soil very liable to cracks and fissures, some of which extend to a considerable depth. Thus the nest of a jerboa, containing two adults, was found 12 feet from the surface at a point immediately to the south of the Gordon College.

The whole site of the town, as mentioned in the last Report, is honeycombed with shallow wells, there being now over 800. These will be considered in more detail when we come to the section dealing with water supply.

Population

Population.—The calculated population for 1908 is—

Khartoum	14,872
Khartoum North	21,672
Total ...	36,544

Some actually place the population of Khartoum North, owing to the recent influx of natives, at 50,000, but I am certain this is an over-estimate. I believe 25,000 is nearer the mark than the figure given, and for Khartoum one works upon a basis of 16,000 in arranging for sanitary needs. Of this 16,000 I should say there are some 400 British (with the British regiment 1000), about 3000 other Europeans, mostly Greeks and Italians, the remainder being chiefly Egyptians, Copts, Syrians, Levantines (a comprehensive term), Arabs, Sudanese (partly Arab, partly negro), and Nilotic negroes. There are as a rule about 3000 native troops—Egyptians and blacks—quartered both in Khartoum and Khartoum North.

Owing to its geographical position and to the river trade, people are constantly coming and going, and hence, as previously stated, malaria infected persons frequently (Plate VII), and at times filaria infected individuals, are added to the number of inhabitants.

Meteorological conditions

Meteorological Conditions.—Through the kindness of the S.M.O. Khartoum, I am able to submit a table of meteorological conditions compiled by Sergeant Squire, R.A.M.C., attached E.A. The recording work for the Egyptian Survey Department has recently been taken over by the laboratories, and is under the charge of Mr. Goodson, Assistant Chemist. The following results give a very fair idea of the kind of climate enjoyed by Khartoum. Some of the later humidity figures were not worked out, but the mean may be taken at about 38 per cent.

PLATE VII

R. D. Muir

MALIGNANT MALARIA

Amœboid forms of parasite, one of which resembles a trypanosome in shape and in the arrangement of the chromatin

Giemsa Stain × 1000 *diam.*

EXTRACTS FROM METEOROLOGICAL OBSERVATIONS TAKEN AT KHARTOUM

Year	Month	Monthly mean maximum	Monthly mean minimum	Monthly mean Humidity per cent.	Total Rainfall	Highest Temperature during the year	Lowest Temperature during the year	Prevailing Winds	Remarks
		° C.	° C.		MM.	° C.	° C.		
1902	July to December	39·0	23·4	47	116·4	—	—	S.S.E. & S.W.	No records prior to July, 1902
1903	January to July ...	26·9	11·6	31	Nil	45·0 in April	6·0 in January	N.N.E.	
1903	July to December	38·7	25·1	36	17·6			S.S.W.	
1904	January to July ...	31·69	16·31	32·9	Nil	45·0 in April and May	7·0 in December	N.N.E.	
1904	July to December	39·10	25·16	41·7	34·5			S.S.W.	
1905	January to July ...	32·8	14·8	36	Nil	45·5 in June	8·3 in December	N.N.E.	
1905	July to December	39·5	26·0	42	15·52			S.S.W.	
1906	January to July ..	31·81	14·39	—	Nil	45·5 in April and May	10·0 in January	N.N.E.	
1906	July to December	38·1	26·16	—	90·4			S.S.W.	
1907	January to July ...	33·19	15·92	—	Nil	45·3 in April	7·7 in January	N.N.E.	
1907	July to December	37·47	24·95	—	188·0[1]			S.W.S.	
1908	January to middle of May	30·5	13·85	—	Nil	—	—	N.N.E.	

[1] NOTE.—In 1907, August was the month in which most rain fell. The heaviest daily rainfall was on August 15th, and amounted to 45 mm.

From about the middle of November to the beginning of March, the climate as a rule is excellent, with the exception of occasional hot snaps, often occurring about the end of December or beginning of January, and high winds associated with dusty days in February. With these exceptions Khartoum enjoys bright sunshine, a dry heat tempered by cool breezes—occasionally too cool, perhaps—and comparatively cold nights. There is not, as a rule, however, that sudden change in temperature so liable to induce abdominal complaints and chills. On the whole, during these favoured months, the climate may be said to be equable. It will be seen that the lowest temperature in the year is usually recorded in January or December. Climate

From March onwards the temperature commences to rise, and attains its maximum in April, May, or June. From the beginning of July to the end of September may be termed the rainy season proper, though a few showers may occur in May and June, and there may be a considerable fall in October. One has known a few drops of rain occur in March, but, as will be seen from the table, the rain-gauge record for the first six months is invariably nil. The months of May, June, and July especially are, as a rule, made exceedingly unpleasant by the visit of sand-storms, which may turn day into night and night into a period of torment. They usually sweep down upon the town from the south, and are sometimes followed by torrential rain and accompanied by thunder and lightning. They vary much in frequency and duration. Sometimes there may be three or four in the course of a week, at other times a week or ten days may elapse without any such disagreeable exhibition. They may last a few minutes or many hours. One of a peculiar type endured for 48 hours, and well-nigh rendered life unendurable. Rainfall Dust-storms

These haboubs have a marked effect on health conditions, as they tend to occur about nightfall, often ruin a night's rest, and may carry infected dust into food and drink, while the worry and annoyance to which they give rise, play no small part in producing that nervous irritability so characteristic of the Tropics.

The rainfall, as will be noted, varies within considerable limits. In some years there are only a few heavy showers, in others, rain falls frequently over a period of several months, and the town, ill-prepared for such deluges, is repeatedly flooded, necessitating the construction of emergency trenches, and entailing considerable trouble and discomfort. At the same time rainy summers are usually cool summers, and thus bring their own compensation.

The damp period of the year, such as it is, occurs in September and October, and it is at this time that hot unpleasant nights may be experienced. Otherwise the nights all through the summer are comparatively cool, although, of course, this is not the case inside houses, which have been heated by the sun all day until they resemble ovens. The cool night is experienced by sleeping on the flat roof of the house or well away from it on the ground.

Conditions modifying the climate

There can, I think, be little doubt that proximity to the Nile modifies the climate of Khartoum, which is certainly slightly different from that of the desert villages to its immediate south. Doubtless also the presence of numerous gardens, plays a small part in adding humidity to the air and diminishing the temperature. On the whole, however, Khartoum possesses a desert climate with all its advantages, and though at certain periods distinctly trying and disagreeable, it cannot be termed unhealthy or relaxing. What ill effects it produces are to be attributed to its monotony and to the action of intense sunlight and heat on the nervous system, together with the irritation induced by the haboubs. These latter, indeed, to some extent, play the part that mosquitoes enact in other parts of the Tropics, that of keeping their unfortunate victims awake and miserable, and this leads us to the consideration of the—

Mosquito work

Mosquito Work.—On this occasion there is no need to enter much into detail regarding the mosquito brigade work in Khartoum. After nearly five years' experience we are in the position of knowing, with considerable accuracy, what can be accomplished in the way of mosquito reduction work in Khartoum and Khartoum North by a brigade of seven native inspectors, controlled by a couple of British sanitary inspectors. One of these latter is responsible for Khartoum, the other for Khartoum North, while the steamers and boats are looked after by a special native inspector. It has been found that of the places liable to become infected, some 800 in all, these being for the most part wells, the number infected can be kept at from 3 to 4 per cent. In the summer after heavy rain the number may rise to 7, 8 and even 10 per cent., but is quickly reduced. With the means at our disposal we have not been able to completely abolish the mosquito, but that insect is now distinctly rare in Khartoum, and is, as a rule, only represented by one species, *Culex fatigans*. It is true that occasionally *Stegomyia fasciata* has re-appeared, but it has never gained a footing in the town. The same is true of the anopheline, *Pyretophorus costalis*, and as regards this mosquito a few notes may be of interest.

It has recurred on several occasions, but only once did it establish itself for any time, and, as previously, its presence was associated with a small outbreak of malaria. The facts are interesting.

An outbreak of malaria

The mosquitoes, which bred out in river pools above and beyond the confines of the town, acquired their infection from old and recrudescent malaria cases in the British Barracks. Several men sleeping near these cases in hospital developed a quartan infection. The next victims were three out of four boys, who, it was found, were accustomed to sleep under an electric light at the Gordon College Workshops—the building, be it noted, which is next the British Barracks on the west; following this a Government official was attacked, and about a week before he fell ill I saw, but failed to kill, a female *Pyretophorus costalis* in the house adjoining the one in which he lived. In all these cases the infection was quartan and locally acquired. The only other case, cropping up at the time and also quartan, was that of a cook at the Grand Hotel. With the destruction of the few larvæ found, the small

W. Beam

Fig. 9.—Pools left by the falling Blue Nile, opposite the Eastern Section of Khartoum

The presence of fish in these pools, as a rule, prevented mosquitoes breeding out in them

W. Beam

Fig. 10.—Pools left by the falling Blue Nile in the Sandbank, East of the British Barracks, Khartoum

Anophelines bred out in some of these pools which did not contain fish epidemic came to an end. Curiously enough, adult mosquitoes were never seen at the British Military Hospital, and the number present must have been very small.

Very occasionally other species are introduced, probably by the steamers. These are mentioned by Mr. King (*see* Report on Economic Entomology).

Mosquitoes in old Khartoum

There is still need for constant watchfulness, and it is worth remembering that both Sir Rudolph Baron von Slatin and Father Ohrwalder, of the Austrian Mission, testify to the fact that in the old days Khartoum was a perfect hot-bed of mosquito life. Indeed, the latter has stated that he has been driven to go and stand up to his neck in the Nile to escape the attacks of these voracious blood-suckers. In the Second Report one quoted Schweinfurth as to the prevalence of malaria, and it is remarkable in what very tiny collections of water *Pyretophorus costalis* will breed. The smallest of puddles amongst the stones by the river-edge, so long as it lasts for any time (and this is often the case owing to percolation through the sand), will serve the purpose, and such places are very apt to be overlooked. A good motto for the brigade would be, "Do not put too much faith in the native inspector." If well watched and controlled he does admirably, being remarkably quick at detecting the smallest larvæ; but he cannot be always trusted and must be supervised.

Derris as a larvicide

A few experiments have been made in order to test the value of *Derris uliginosa* as a larvicide. In carrying out these I had the assistance of Mr. King.

The roots of the plant were kindly supplied by Dr. Power, of the Wellcome Chemical Research Laboratories in London, but efforts to obtain other species of the plants from Kew Gardens failed.

The following are the details of the tests made. In all cases the water employed was that in which the larvæ were found, and controls were instituted :—

1. November 4th, 1906. Three half-grown larvæ of *Culex fatigans* placed at 1 p.m. in an emulsion consisting of 1 c.c. supernatant fluid from an alcoholic extract of Derris root (gm. 27 in 50 c.c.) in 150 c.c. of water. The emulsion smelt strongly of the drug and was of an opaque colour.

   Result. No immediate effect and no effect after half-an-hour. Condition that night not noted. All the larvæ found dead on the morning of November 5th, 1906.

2. November 7th, 1906. Four half-grown *Culex fatigans* larvæ placed at 10.45 a.m. in 150 c.c. of water containing 5 c.c. of above fluid. Emulsion very opaque.

   Result. No immediate effect. All dead in one-and-a-half hours.

3. November 8th, 1906. Four half-grown *Culex fatigans* larvæ placed at 11.50 a.m. in 150 c.c. of water containing 1 c.c. of the shaken-up Derris extracts, *i.e.* supernatant fluid and debris.

   Result. No immediate effect beyond evidence of irritation, the larvæ twisting and "biting their tails." Two dead and the other two dying in one hour. All dead in one-and-a-half hours.

4. November 21st, 1906. One lively *Culex fatigans* larva placed in a 5 per cent. filtered watery extract of *Derris uliginosa*, a dark reddish-brown liquid with a strong odour. The larvæ died in 25 minutes.

   Eight lively half-grown *Culex fatigans* larvæ placed in 150 c.c. of water to which 1 c.c. of above watery extract added. No immediate effect.

5. November 25th, 1906. One lively *Culex fatigans* larva and one pupa placed in a 2·5 per cent. watery extract as above.

   Result. Larva dead after twenty-one hours; was alive after four hours. Pupa alive after twenty-four hours.

6. November 27th, 1906. No. 5 repeated with same result.

7. November 29th, 1906. Five lively *Culex fatigans* larvæ placed in 1 per cent. watery extract of powdered Derris root.

   Result. Moribund after two hours; all dead in three hours.

8. December 2nd, 1906. Four active *Culex fatigans* larvæ placed in a 0·5 per cent. watery extract as above.

   Result. No immediate effect. One found dead after four hours; others lively. All dead after twenty-two hours except one, which, however, died after forty-eight hours.

9. January 1st, 1907. Several larvæ of *Culex fatigans* and one of *Pyretophorus costalis* placed in a similar 0·5 per cent. watery extract at 11.20 a.m.

   Result. All alive at 1.30 p.m. All dead the following morning.

In order to see if the tannin in the Derris root had anything to do with its lethal action, two larvæ and one pupa of *Culex fatigans* were placed in a 1 per cent. watery extract of

Acacia arabica bark. *Result*: No effect in two hours. The pupa hatched out and the larvæ were alive after twenty-seven hours, although the liquid was of a deep orange-red colour. A 10 per cent. watery extract proved fatal to two *Culex fatigans* larvæ in twenty-one and twenty-three-and-a-half hours respectively.

It is evident that in *Derris uliginosa* we possess a larvicide of considerable potency, but, in the Sudan at least, the difficulty in obtaining Derris root prevents it being used. Moreover, Vogel, who has used the bark of the root of *Derris elliptica*, found that while in a strength of 100 milligrams to 5 grammes of water it killed larvæ in one day, it was also destructive to fish life. It would, therefore, appear that even in those regions where they are indigenous, the various species of Derris have only a limited use as larvicides.

Of more general interest are the recommendations drawn up with a view to the insertion of special clauses in all future irrigation concessions in order to aid in the prevention of malaria. These are as follows :— Irrigation rules

1. Irrigation channels should be constructed on a higher level than the surrounding land, so that when the flow of water in them ceases they may drain dry.
2. They should be constructed of such material and in such manner as to prevent leakage.
3. Their banks and beds should be kept in good repair, and the beds even, to prevent the formation of pools.
4. "Dead ends" of irrigation channels should be reduced to the smallest size compatible with efficiency, so that water will not stagnate in them.
5. Vegetation should be periodically cleared out of the channels.
6. Sluices should be constructed so that there is no leakage to form stagnant puddles.
7. Where possible, fish should be introduced, and kept in the main channels to destroy the larvæ.
8. Lands where water is apt to stand should have proper surface drainage.
9. Crops, such as sugar-cane, rice, and others which require to stand in water, should not be grown within half a mile of any town or village.
10. If an engine or pump should happen to break down, particular care should be taken to deal with stagnant pools, and petroleum should be used where necessary.
11. Cases of malarial fever, and any prevalence of mosquitoes, should be notified to the governor of the province by the manager of the concession.

So far as Khartoum is concerned, these rules are followed out by the Manager of the Sudan Development and Exploration Company at Khartoum North, and though there is a large area of land under cultivation there, it is very rarely that one has to complain of the presence of mosquito larvæ. This shows what can be accomplished by care and attention and a great deal is due to Mr. Harold Hall for his help and co-operation in safeguarding the town.

Clothing.—One had intended making some remarks as regards clothing, but perhaps sufficient has been said on this subject in the Review. Whatever be the hygienic value of the *damoor* (native cotton) clothing, in such general use, it is certainly comfortable, light, fairly durable, and of a good appearance. Combined with black or orange underclothing, it would probably meet every requirement. In the Sudan, true "Solaro" garments seem to lose their colour quickly, and, so far as I know, have not proved a great success. Of more importance possibly is the question of Clothing

Housing and House Construction.—And here I have been fortunate enough to receive the kind help of Mr. W. H. McLean. He has, at my request, written the following paper and prepared the plans illustrating it specially for this Report :— Housing and house construction

Dwelling-Houses in the Tropics

(With special reference to the Sudan)

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The suitable housing of white men in the Tropics is a matter of considerable importance. One of the greatest enemies of such men is the sun, and protection from its injurious effects is necessary. It is known that exposure to an excessive amount of sunlight is harmful, causing nervous and other diseases ; the black man is already sufficiently protected from the injurious light rays by the pigmentation of his skin, and he has, therefore, only to shield himself from the heat rays. The white man, on the other hand, must be protected from both the light and the heat rays, yet he is very often to be found living in houses in the Tropics which are obviously only suitable for temperate climates, and in which even a black man would feel uncomfortable. The native houses are generally well darkened, with only a few small openings, and they are often really healthier than the houses occupied by the white men. Residence in dark houses appears to be practically harmless. The early cave dwellers of Europe carried on the human species for millenniums in perfect health.

Protection from light and heat

The ancient Romans understood the effects of light, and it was one of their axioms that "a man must protect himself from the rays of the sun." The Americans in the Philippines seem to have neglected this, with disastrous results, and in this connection Major C. E. Woodruff, U.S.A.,[1] says that "The Spaniards who lived in the Philippines did not appreciate the dangers of light because they were brunettes and they made but little provision in their homes to escape the dangers. Blonde Teutons in India, on the other hand, see the necessity for this protection, and build great covered porches around their houses for this express purpose. As far as I have learned, Americans are falling into Spanish ways and making no provision to protect themselves from the fatal rays of light. American houses must have big verandahs whose roofs come well down. It is safe to say that there is not a residence house in the Philippine Islands fit for a blonde man to live in. I challenge contradiction of this violent statement.

"The roof of a porch or verandah must come down so low that a person seated in the room cannot see the sky; that is, the lower edge must be about four feet above the floor line, or approximate screens be built to that level."

There are certain important points in connection with a dwelling-house in the Tropics which ought to be borne in mind when either building or selecting a house.

Site.—It is better that the house should not be in the midst of native huts, or near stagnant water. An elevated and dry site, on sloping ground but not in a hollow, should always be chosen if possible.

Foundations.—On a sandy clay, such as is found on the banks of the river Nile, the foundation should be carried deep enough to avoid disturbance by the surface cracks. From 1·00 to 2·00 metres is generally sufficient, and the maximum load on the foundation should not exceed one ton per square foot (1 kilo. per sq. centimetre). If the building is near the river edge this load ought to be somewhat reduced, or the foundation reinforced with steel, to prevent cracking of the walls caused by the rise and fall in the water level and the consequent unequal settlement.

On a site liable to be flooded the ground floor should be at high flood level, and all walls should be substantially built up to that level, and a damp-proof course of bituminous sheeting or other material inserted.

Walls.—In a dry locality, mud walls may be quite satisfactory, and they have the advantage in that they do not retain and radiate the heat like stone or brick walls. Where heavy rains are to be expected it is, of course, advisable to build in brick or stone. The ceilings need not be higher than 4·00 metres, which is sufficient for ventilation purposes. Masonry walls should be protected by verandahs from the direct rays of the sun, as, if not so protected, they will heat up during the day and radiate the heat all night.

Ventilators in the walls near the roof are a great advantage, and they should be made to

[1] Woodruff, C. E., "The Effects of Tropical Light on White Men." London: Rebman, 1905.

close in order to keep out dust. Window openings in walls not protected by verandahs should be few and small.

Roofs.—All roofs must be thick enough and of a proper material to stop both the heat and the light rays. Roofs of corrugated iron alone, or of boarding covered with some waterproof material, are not sufficient protection, but if the underside of the joisting is wood lined, and an

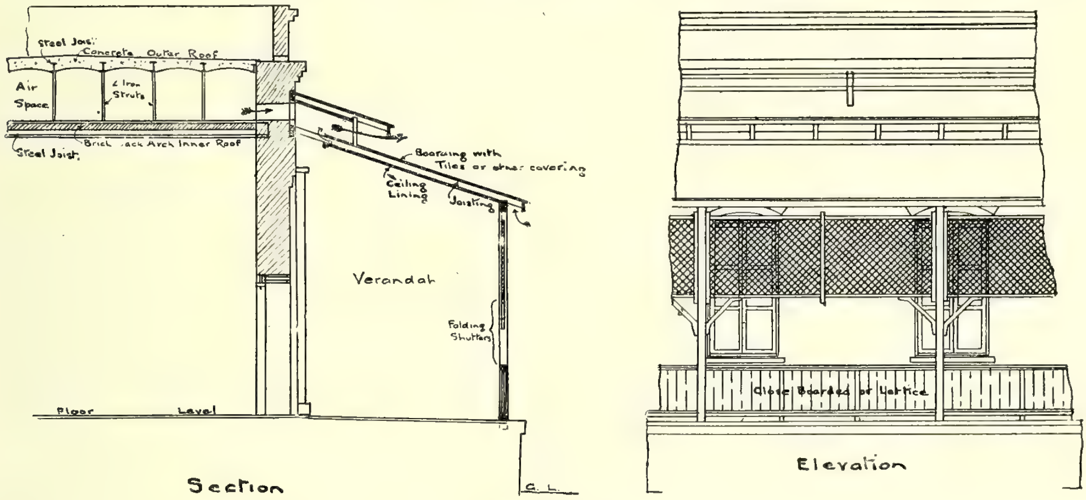
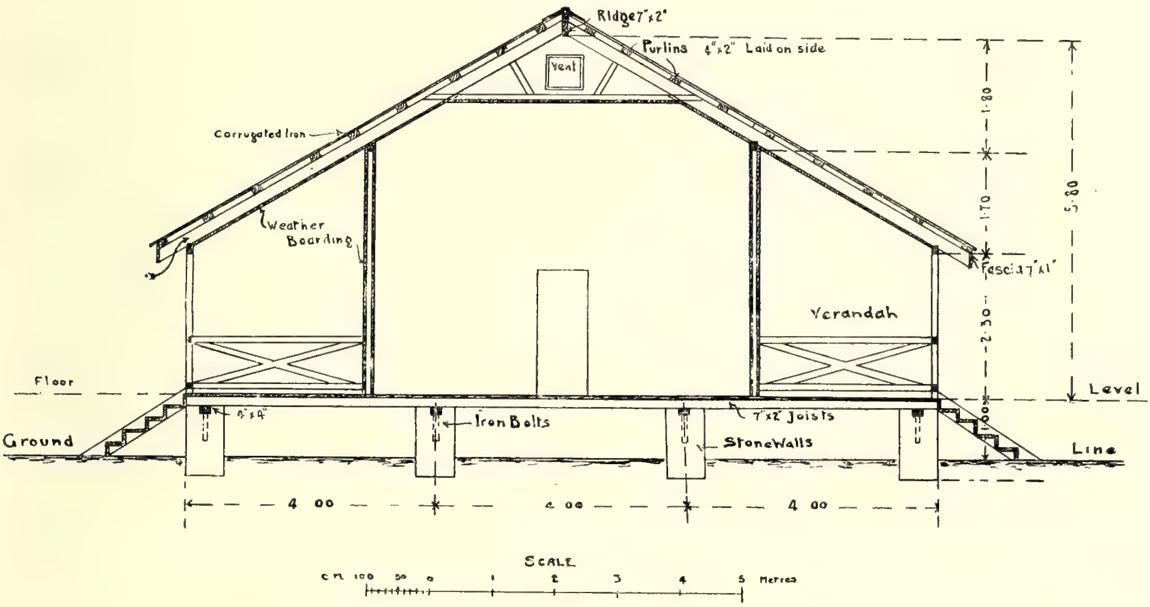


FIG. 11



W. H. McLean

FIG. 12

FIGS. 11 AND 12.—DESIGNS FOR DWELLING-HOUSES IN THE TROPICS

air space left between, the result is more satisfactory. A common form of roof is of "zibla" (a mixture of stable manure and earth), which is laid on boarding or on straw matting and rope netting. This is quite satisfactory, especially if a wood ceiling lining is added, and the "zibla" is protected from the weather by a waterproof covering.

Another common form is of rolled steel joists with brick jack-arching between, and covered with a waterproofing material. This appears to be one of the most satisfactory types of roofing.

If constructed as a double roof, as shown in section, Fig. 11, it is of course by far the most desirable arrangement. The outer roof is of very light construction, and the air space between prevents any heat-rays passing through, and the light-rays are completely cut off.

Access to the roof should be given by an inside stairway, and the parapet walls raised, or screen walls built to provide sleeping accommodation.

The disadvantage of the flat roof is the difficulty of keeping it watertight. In localities with a heavy rainfall the sloping roof is therefore preferable. Fig. 12 shows the cross-section of a wooden bungalow with a sloping roof, which is extended to form the verandahs on both sides.

Verandahs.—These should be provided on all sides of the house, or at least on the sides subjected to the sun's rays. They should be not less than three metres wide, and constructed of timber if possible, which is cooler than masonry, as it does not retain the heat. They should come well down in front to a level at least half the height of the window openings, and it is recommended that they should even come down to within four feet from floor level. All verandahs should be ventilated on the roof near the ridge, and should have a ceiling lining with an air space between the joists, as shown in Fig. 11. The same figure also shows how the whole verandah may be enclosed by having a close boarded or lattice parapet and folding shutters above. Such a verandah, from which all hot air is excluded during the day, is sure to be very comfortable in the evening.

Bathroom and Latrine.—The bathroom and latrine may be either detached from the house and approached by a separate verandah, or it may be a separate room of the house approached from the verandah. An outside latrine placed against a boundary wall to facilitate cleansing, is the best arrangement where a conservancy system exists.

Servants' Quarters.—The outhouses and servants' quarters should be well away from the house, but the kitchen might be placed somewhat nearer and connected to the house with a covered passage if possible.

Colours.—The colour of the materials or of the paint, affects to some extent the coolness of the house.

In this connection, Major Woodruff says that "the glare from white houses is very harmful. I have seen marked suffering in army posts before we abandoned the dangerous practice of painting everything white, and resorted to the colours found in nature to which our eyes are adjusted—the greens, dark yellows, and browns. It is a matter of common knowledge that, in a city, the glare from white houses is a great nuisance to the neighbours, and has been known to cause serious eye diseases. Hence, no white houses should be permitted in cities; the red colour from the brick is bad enough, but the best colours are those above mentioned. In the Tropics these rules are doubly important, for the glare from the whitened walls is dreadful.

"In addition, white lead is known to absorb the infra-red rays as well as lampblack, and consequently it is a 'warm' paint in the sunshine, and will cause a tropical house to heat up."

General.—When planning the house, care must be taken that so far as possible every room will get some share of the prevailing wind. The coolest houses are those with the rooms arranged round a central hall or courtyard, and those having two floors are generally preferable. Figs. 13 and 14 show plans of suggested arrangements.

The house should be surrounded by a drain, and the water from the rain-water pipes should be carried well away from the house. Dr. W. J. Simpson [1] recommends that there should also be a pavement all round, sloped away from the basement, or a gravel walk; if the gravel is sharp it forms an obstacle to snakes. Beyond this, short grass is best, and all trees should be so far away as not to obstruct the ventilation or cause dampness. Any excavations

[1] "The Maintenance of Health in the Tropics."

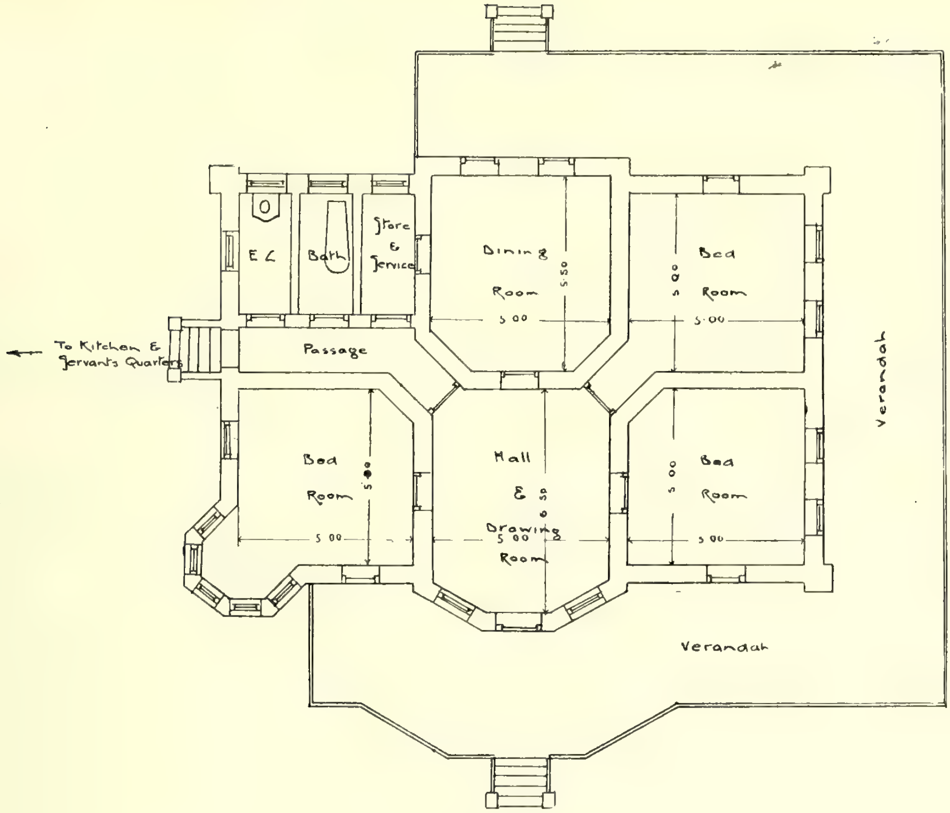


Fig. 13

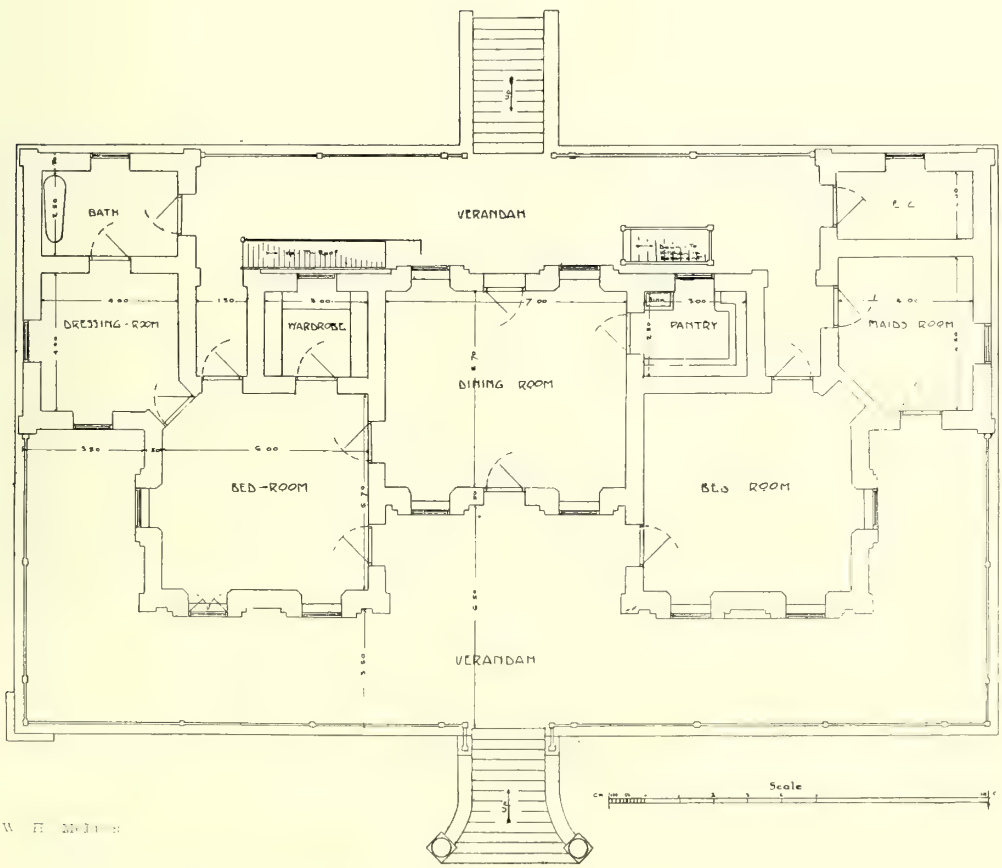


Fig. 14

Figs. 13 and 14.—Plans for Dwelling-houses in the Tropics or depressions in the ground around or near the house should be levelled up to prevent pools forming during the rains.

Special door and window frames, covered with fine wire netting, should be provided in localities infested by mosquitoes or other insects. All windows must have outside sun-shutters with louvres.

Woodwork should be protected from the attacks of white ants by painting with any of the special preservatives now on the market.

The foregoing are merely general rules and suggestions; the actual type of house best suited to any given locality will depend upon the conditions obtaining and the materials available.

Continued BY THE DIRECTOR

Conservancy

Conservancy.—Under this heading we consider

1. Sewage collection and disposal.
2. Waste water collection and disposal.
3. Refuse collection and disposal.

The old method

Latrine buckets, old type

Crowley carts

1. The bucket system is in vogue, but, owing to the customs of the majority of the inhabitants, one cannot speak of a dry earth system. At first Khartoum was served by the ordinary pattern of latrine bucket, Fig. 15, the Crowley cart, Fig. 17, and a system of deep trenches. One need scarcely enlarge on the abominations and danger of the so-called "ironclad." The bucket is emptied into it, and often on and over it, so that very frequently streams of filth travel down the back of the receptacle and drip upon the ground. This insanitary juggernaut pursues its way, surrounded by a cohort of flies, and emitting a disgusting stench. Its contents, too, often splash and slop over, the cover being rarely closed by the careless native, and, when closed, being of little use to prevent leakage. Occasionally the receptacle tilts, turns upside down, and discharges its contents upon the public thoroughfare.

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FIG. 15.—SANITARY PAILS, KHARTOUM

On the left, the old type, now abandoned

In the centre and on the right, the new type, with air-tight cover

In wet weather it was not uncommon for several carts to stick fast in the mud or in the heavy sand outside the town, so that, in despair, one had to order the contents to be buried on the spot. I wonder how many of the inhabitants ever saw a Crowley cart emptied at the trenches! It was an instructive sight. The sides of the trench became fouled, the cart became more fouled than before, and the men became fouled in many cases. Then this uncleanly vehicle, half scraped out, went rolling back to town for another load. It is well-nigh impossible to keep these carts clean, and utterly impossible to work them in a sanitary manner. Worse than all, the buckets, after being emptied into them, were cleaned on the spot, cleaned (save the mark!) with a pot brush and a handful of dry sand. This was going on in Khartoum day in and day out, and the surface soil was becoming more and more contaminated. Thanks to the powerful sun, even this insanitary state of matters did not seem to be prejudicial to health; but one maintained that, given a wet summer, its effects would be speedily apparent. Such a summer occurred before there had been time to get the new system into working order, and the result was an epidemic of dysentery, not very severe perhaps, but sufficiently annoying, the cause of considerable distress, and incapacitating a considerable number of people for work. Fouling of surface soil

After carefully considering the condition of things in Khartoum, it was resolved to abolish the Crowley cart and to substitute a system whereby the bucket, and its contents, properly fitted with an air-tight lid, could be removed and carried to the place of ultimate disposal, its place being taken by a clean pail. The dirty bucket could then be thoroughly cleaned at a spot well away from the town and returned to take the place of the one in use. At the same time it was resolved to do away with the old brick latrines, which were built on a very bad principle, were unsightly, liable to become flooded, and had, in most cases, fallen into disrepair, so that they could not be kept clean. A glance at the map, *page* 75, and at Figs. 18 and 19, will give an idea of the system now in vogue. The type of bucket to be employed was the subject of considerable thought. Eventually that used in the enteric outbreak at Lincoln was decided upon, though one was a little doubtful as to how the rubber ring, which forms the seal, would stand the climate. As these would be wetted every day, it was hoped that they would serve, and this has proved to be the case. The buckets have, indeed, proved quite successful from a sanitary standpoint. Their only drawback is that, though very stoutly built of galvanised iron, they are apt to become damaged. This applies more especially to the spring clips which fasten down the lids, while the necessity of piling the buckets on the top of each other on the carts and trollies tends to injure the lids. The question of having upper platforms for the top rows was considered, but it was found cheaper and better to have the buckets repaired by the Sanitary Service blacksmith. One other point may be noted—the tendency for rivets to work loose and fall out. It is evident that careful inspection is necessary. A special man was appointed to supervise the pails and collect any which were damaged. He is fined if such buckets be found in use. The new method Latrine buckets, new type

Spare rubber rings should be stored in wet sawdust.

With these precautions the buckets answer admirably. They are not too heavy, although they have a capacity of four gallons, and as they have undergone an eighteen months' trial we know the best and the worst regarding them.

It will be seen that the buckets are collected on special low carts drawn by camels (Fig. 18). These animals are better than mules or oxen. They draw a heavier load than the mules, are more tractable, and the men understand them better, while they move much more rapidly than the slow oxen. Sanitary carts

The carts discharge their loads at special collecting stations. Here the buckets are loaded on to trollies, which are drawn along a tramway by mules or camels to the place of ultimate disposal. Trollies

The system is now the same both for Khartoum and Khartoum North, and has been in vogue since January, 1907. It was a matter of considerable difficulty initiating the change, and I would here take an opportunity of mentioning the good work accomplished by Mr. John Newlove, who was at that time our sole British Sanitary Inspector. Only those who have had to deal with the lowest class of native, and have experienced his curious aptitude for doing things in the wrong way, or in the very easiest way for himself, can have any idea of the trials and vexations Mr. Newlove had to endure for several weeks. On the whole, however, the cleaners and drivers adapted themselves remarkably quickly to the new conditions. Efficient inspection means everything in such a system of sewage collection, and we may here briefly consider its advantages and drawbacks.

Advantages of new system

1. *Advantages.*—(*a*) There is no fouling of the soil round houses and public latrines, or at least this is reduced to a minimum. Latrines in the lowest class houses are often very filthy, and the buckets stand in a foul bed, part of which is withdrawn with the bucket. Here we do get some fouling, but it is not the fault of the system, and means exist for dealing with this type of nuisance.

(*b*) There is no fouling of the soil during transit.

(*c*) The fly nuisance and danger is greatly lessened, and when, as is now the case, the carts and their loads are sprayed with weak formalin solution, will probably be wholly abolished.

(*d*) The stench nuisance is very nearly absent, at any rate it is much less than in the days of Crowley carts.

(*e*) The buckets are properly cleaned, and are returned in a state which possesses no attraction for flies.

(*f*) It is possible in the case of houses where cases of enteric fever or dysentery exist, to supply special red buckets, the contents of which can be incinerated.

(*g*) The cleaners prefer the new method.

Disadvantages of new system

Disadvantages.—(1) Expense, but this is covered to some extent by the prices obtained from the sale of buckets, while the accompanying careful inspection results in the conservancy rates being properly collected. As a matter of fact, the conservancy receipts in the last few years have risen from about £E400 to well over £E2000 and this is only very partially due to increase in population. The initial expenditure is comparatively small, but the upkeep is somewhat heavy. It is well to remember, moreover, that so long as there is no waste, money expended on proper sanitation is money well spent, and though I have placed this item first in the list of disadvantages, from the point of view of the Medical Officer of Health I would be justified in putting it last.

I append a table of the total expenditure incurred, as regards the sanitation of the two separate towns of Khartoum and Khartoum North, during the last six years, and compare it with a table of receipts, the latter being almost wholly derived from the conservancy system. The excess of expenditure over receipts is stated in a third table :—

Year	Total Expenses	Total Receipts	Excess of Expenditure	
	£E	£E	£E	
1903	1,685	848	837	
1904	2,070	721	1,349	
1905	3,607	963	2,644	
1906	10,797	1,575	9,222	New conservancy system inaugurated
1907	6,854	2,732	4,122	
1908	7,655	3,000	4,655	
Total	£E32,668	£E9,839	£E22,829	

To the uninitiated these figures may, and do, appear alarming, but when one considers that they represent the expenditure necessary for the abolition of a faulty system and the establishment of an entirely new system of conservancy in two tropical towns, and further represent the total expenditure for six years on all matters concerned with the public health,

FIG. 16.—MAP OF KHARTOUM, SHOWING SANITARY SYSTEM

C.S. = Conservancy Station

C.T. = Conservancy Tramway

save water supply, vaccination and those services, such as street cleansing and watering, which are not as a rule administered by the Medical Officer of Health, then I submit that the outlay has not been excessive but the reverse. Nowhere can sanitary measures be made to pay a profit in hard cash, least of all in the remote Sudan, in towns inhabited chiefly by natives and where the cost of transport of material from either Egypt or England is very high.

One cannot here go into all the details of expenditure, but wages, which are high in Khartoum, constitute the principal item, and there are included the salaries of the sanitary staff. Against these figures must be placed those of increase of population and the statistics dealing with the prevalence of infectious disease. In the Tropics, even more than elsewhere, health spells money, and it is to be remembered that in the old days Khartoum was a notoriously unhealthy spot.

It is always difficult to obtain money for sanitation, but in the past it has been granted in a fairly liberal manner. It is hoped that in future the claims of the public health will receive an equal, or even greater, share of attention by those responsible for the distribution of funds.

The Sanitary Service supplies one bucket free to each private latrine, the tenant or occupier has to purchase the other. In the very poor parts of the town both buckets are supplied free when considered necessary.

(2) The system depends on human labour—on native labour—and this is certainly a drawback. At any moment conditions may arise which may seriously interfere with its working, such as war, pestilence, or even strikes, which are not unknown in Khartoum. Again, native labour is never first-class, but its faults can be combated by efficient inspection. For instance, this is required to prevent the cleaner emptying the contents of one bucket into another and thus saving himself trouble and lightening his cart-load. There are now three trained and certificated British Sanitary Inspectors, but a fourth is required.

(3) By general consent a water-carriage system properly conducted is the best, for there are more opportunities for the spread of disease with a bucket system, however well it may be managed. At the same time, owing to its position and surroundings, only a Shone and Ault or Liernur system would serve Khartoum, and its installation would cost about £250,000. The engineering work would have to be of a high order, and an ample water supply would be a necessity. Neither of these desiderata are available at present.

I believe the present system will serve the town for from seven to ten years, unless indeed the latter undergoes such rapid extension as to prevent us coping with its increase. The bucket system has this disadvantage, that it cannot be extended beyond certain limits without undue expenditure as regards upkeep.

(4) This system provides only for the disposal of sewage. A water-carriage system could be made to provide for the removal of waste and storm waters as well.

Latrines, private and public

A word or two regarding the latrines. Sanitary by-laws secure that private latrines shall be of proper construction, with cement floors and bucket doors opening on a lane or street so that the buckets can be easily collected. Some of the latrines in the old houses, and, sad to say, in certain of the Government houses, do not fulfil this latter condition, but slow progress is being made in getting these faults remedied. Nearly every house in the town now possesses a private latrine, and the plans of all new houses have to be approved by the Medical Officer of Health. The type of public latrine is shown in the plans (Fig. 21). They are of a good pattern, though no doubt they might be somewhat improved. The cement floor is a weak spot, for good cement work cannot be obtained, and the "skin" soon cracks, but in Khartoum it is not possible to obtain a cheap and reliable substitute, as has been done in Burma (*vide infra*). These latrines are not very expensive, are easily erected, allow of a fine sweep of air through them, are readily cleaned and do not offend the public rights. The walls and roof are of painted corrugated iron, the seats of earthenware glazed sanitary slabs.

W. Beam

Fig. 17.—Crowley Cart, now abolished

W. Beam

Fig. 18.—Conservancy Camel Cart. Khartoum Sanitary Service

W. Beam

Fig. 19. Conservancy Mule Trolley. Khartoum Sanitary Service

Trenching ground

The place of final disposal, both at Khartoum and Khartoum North, is shown on the map (*page* 75). At Khartoum it is well away from the town, lies in an out-of-the-way corner, and the land drains towards the White Nile away from what may eventually be the town water supply, which is about 3½ miles distant from the trenches.

The chief disadvantage to the place, which is the only suitable one, is that if the Nile again rose to its highest maximum, a small portion of the trenching area would be submerged. As a rule the water level does not come nearer than a quarter of a mile to the most westerly line of trenches.

The deep four-foot trenches previously in use have been abandoned for shallow trenches about 18 inches deep, 16 feet long and 3 feet wide. Nine-inch trenches were tried, but were found too shallow.

Even with proper trenching, flies breed out in great numbers, and the surrounding ground on which the buckets are cleaned is fouled. To some extent this can be remedied by spraying with formalin and by drenching the surface soil with the hot water in which the buckets are washed. This is derived from the refuse destructor, into which boilers were fitted, a good supply being available. The buckets receive a final wash in a disinfectant and deodorant solution.

So far, the weak spot in this disposal scheme has been the absence of any attempt at cultivation. A large area of soil, about eight acres in all, has been trenched, but there has not been a sufficient supply of water to enable us to grow such crops as might be utilised in the feeding of the municipal animals. Moreover, wages being comparatively high and a considerable number of men having to be constantly employed in digging and filling in the trenches, the annual cost of this method is by no means insignificant. It was with a view to obviate these disadvantages, and at the same time to carry out some experimental work likely to be useful in the future, that I devised a plan of treating the sewage by a septic tank process. I am not aware that such a scheme has been previously attempted with a so-called dry earth system. I hoped it might serve because, as stated, very little earth is used in the pails. At the British Barracks, where we have taken over the conservancy, izal is employed, and sand is used by the majority of British residents, but elsewhere this is not the case owing to the lavage practised by Mohammedans. Hence the sewage may be described as semi-liquid, containing as it does a considerable quantity of sullage water. Again I thought that by using iron tanks exposed to the full power of a tropical sun, great heat would be generated, tending to produce rapid biological action and a speedy liquefaction of the solid part of the sewage. It was evident that labour would be saved, that the building of a good cleaning platform of brick and cement would prevent fouling of the surface soil, and that the disposal of the excreta would take place much more rapidly—a matter of some import. At first an open and a closed metal tank were used, and the pail contents were diluted with water derived from a well served by a hand pump, the proportion being 1 of sewage to 3 of water. It was remarkable what a good effluent could be obtained in 48 hours, and how little sludge remained. The effluent was quite good enough to be run directly upon the soil, and several crops of dura were grown on the land irrigated by it. Unfortunately, the smell from the open tank constituted a nuisance when the wind shifted to the south, and, as one was anxious to test a brick and cement tank against an iron tank, one of the former type was erected and the open metal tank was converted into a filter tank.

Septic tank system

Sewage farm

All this took time to arrange and complete, and hence I am unable to give any full account of the results obtained. It is evident, however, that to make the process a success, an engine and pump to furnish sufficient water from the well will be a necessity. It is essential that the pail contents be diluted. One has tried keeping the crude pail contents in the brick and cement tank. Liquefaction certainly takes place, and there is not a great deal of sludge, but the effluent is strong, and speedily undergoes offensive decomposition.

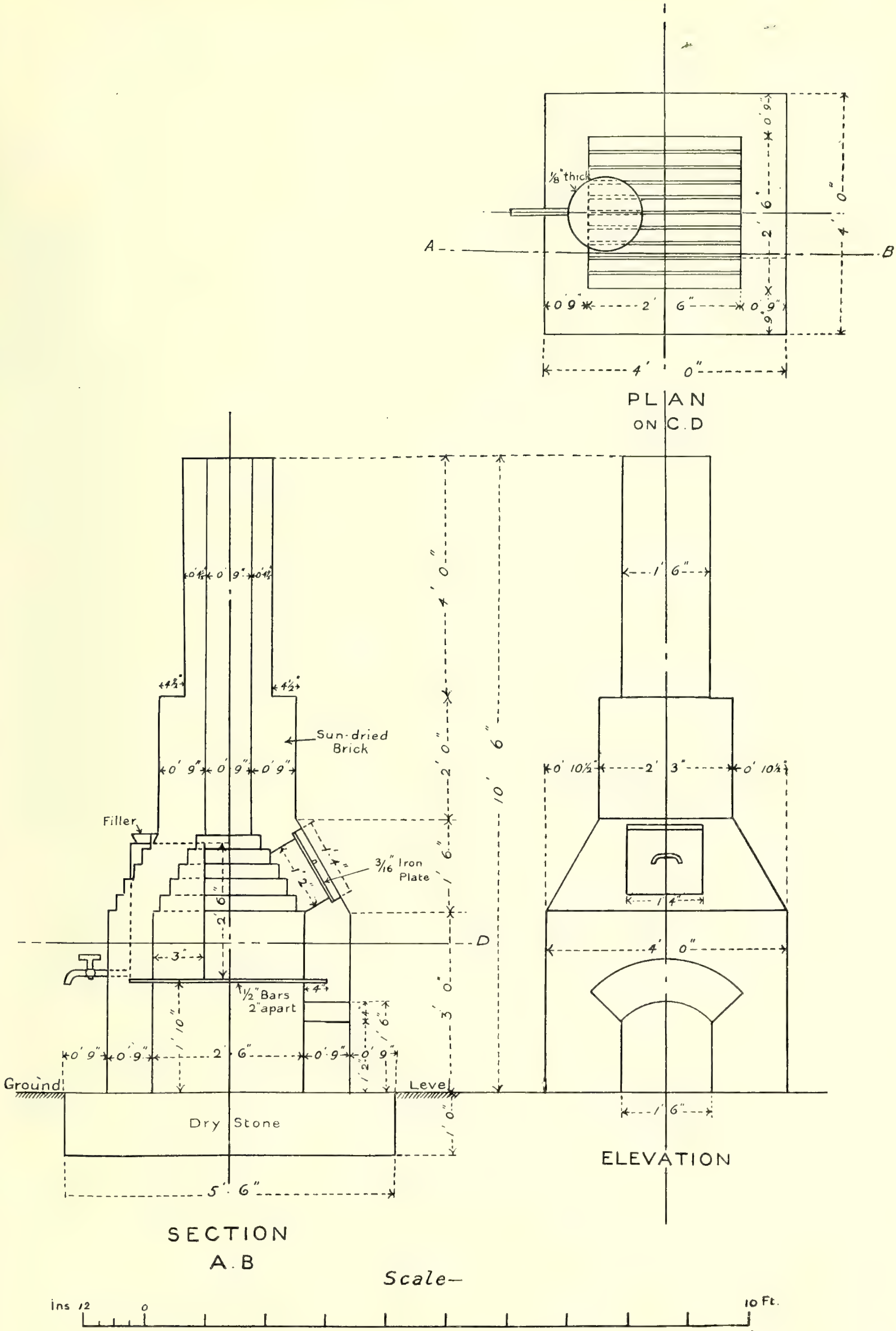


Fig. 20.—Useful Type of Incinerator, modified after Morris

The closed metal tank has not yet had a fair trial, and it is evident that the results will have to be controlled and tested by chemical and bacteriological analyses. In any case, the scheme is likely to furnish useful information against the day when a water-carriage system and proper biological tanks are in existence.

At Khartoum North trenching alone is in vogue. The soil here, a good sandy loam, is very suitable, and the quantity of sewage to be dealt with is much smaller. The trenches are now not in the best position, though at the time the land was chosen no fault could be found with it. The extension of the town, however, necessitated by the important work on the Nile Bridge, has altered matters. It is hoped to carry the tramway system further out into the desert. At the same time, beyond occasional nuisance caused by unpleasant odours borne by the north winds, these trenches have not caused any trouble or illness, so far as can be ascertained. Though both towns are now well served by public latrines, it has been found impossible to prevent the native easing himself wherever and whenever possible. He takes advantage of the least bit of cover, and the nuisance is specially prevalent after darkness has set in. Apart from the breeding facilities afforded to flies by the scattered masses of human excrement, the river bed at low Nile gets badly fouled, and though during the dry season little danger is to be apprehended, the outlook is different with a rapidly rising river and with the advent of rain. Moreover, at Khartoum North the increase of the native population has been so great that one cannot hope to meet its requirements by going on building large latrines. The people live in huts and tukls, and though they keep their villages wonderfully clean, the surrounding desert soon becomes an insanitary area. It was evident that the only way to cope with this state of things was to erect small incinerators.

Incinerators for excreta

The type adopted is shown in the plan, Fig. 20, and is a modification of that recommended by Morris.[1] Sweepers are employed to clean the ground. The material, if necessary, is dried in the sun, and is then burned, a little oil being used as fuel. So far only two incinerators have been erected, one at Khartoum and one at Khartoum North. They have been found to act well, to cause no nuisance, and they are cheap.

It is hoped to increase their number next year. I understand that the Sudan Medical Department intends to follow suit, and to deal with the excreta from the long line of native villages to the south of Khartoum on this principle. This will certainly prove an advantage, as during the haboub season the insanitary condition of the ground near these "daims," as they are called, was, I think, a source of danger to the town. It is in India that this system has been chiefly advocated and adopted.

Hamilton[2] deals with the use of small incinerators for cantonments, and their form has been elaborated by Haines,[3] who introduced the boilers for urine, and who states that the secret of avoiding smell is to have a good filtering layer of rubbish on the top of the material to be consumed.[4]

The pail system is admittedly on the plan adopted long ago at Singapore and elsewhere. Last year several interesting papers appeared on this subject, and we specially note those from Burma, where it is termed the "Bassein" system. There are some points of comparison

Comparison with Burmese methods

between the Burmese and Khartoum methods which call for notice. Entrican[5] describes his district conservancy in detail. The buckets have a lid of this shape  which is pushed down inside the pail and seals it effectually. I fear the raised edge would speedily

[1] Morris, W. A. (October, 1907), "Incinerators in Cantonments." *Indian Medical Gazette.*

[2] Hamilton, H. (April, 1907), "Small Incinerators." *Ibid.*

[3] Haines, H. A. (June, 1907). *Ibid.*

[4] Other references to this system will be found in the *Indian Medical Gazette* for July, November, 1908, and in the *Journal of the Royal Army Medical Corps* for September, 1908.

[5] Entrican, J. (February, 1907), "Some Notes on the Conservancy of the Smaller Towns in Burma." *Indian Medical Gazette.*

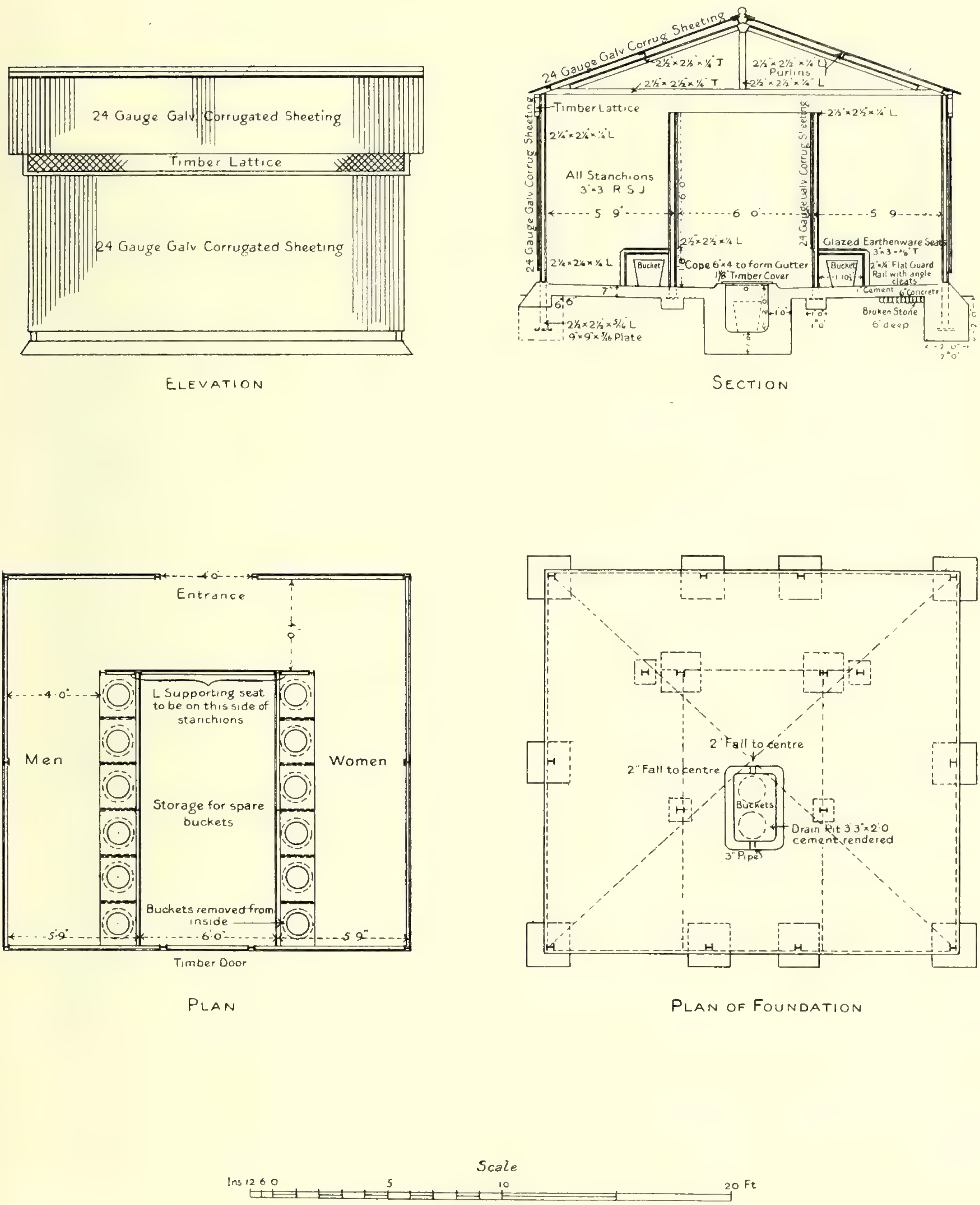


Fig 21.—Elevation, Section and Plans of Public Latrine, Khartoum

become bent in Khartoum, rendering the cover useless. I am inclined to think our type of lid, though more expensive, is preferable, although the rubber does get cut through at times and the clips become damaged.

Otherwise the schemes seem very similar, though no light railway is employed by Entrican. This, however, is the case at Bassein, where such is in use, fitted with turn-tables. Here also they have a plan of painting one set of buckets with a red band, the other with a black band. This is to ensure that the cleaners change the buckets properly. Thus, on one day red-banded buckets will be in use, on the succeeding day black-banded, and so on. The adoption of this principle has been considered for Khartoum, but we have such a large number of buckets, and the work is so arranged that it would not be easy to carry it out. One prefers to rely on constant inspection and the infliction of heavy penalties for faulty work.

Entrican has wood ashes, or sawdust, placed in the clean buckets. These substances are light, absorbent, and prevent splashing. They are not easily obtained in Khartoum, and would present no advantages, besides being undesirable for the tanking process. One has, however, advocated the substitution of the dry sand by a little petroleum, which prevents smell, keeps away flies, and lessens the weight to be carted. The number of sand users is small, but I have not been able to introduce the petroleum system so far, as it entails slight extra expense and trouble on the part of the householder, and for some æsthetic reason the Governor was opposed to it. Its only real disadvantage is the risk of splashing at the time the pail is in use.

Special sweepers' quarters are advocated; from experience I know this to be advisable. They exist in Khartoum, and efforts will be made to house the cleaners at Khartoum North.

Entrican recommends one acre to every 109 inhabitants, but then Burma has a moist climate and a heavy rainfall. At Khartoum we have one acre for every 2000 people, and so far this allowance has proved sufficient. At Khartoum North we can get as much land as we require.

No land is trenched a second time without being cropped—a wise provision.

He allows one *public* latrine seat for every 60 inhabitants. This seems a liberal allowance, but much depends on the habits of the population, and on the number of private closets.

Several clearances of buckets in the day have to be carried out. In Khartoum double clearances are required for the civil and military hospitals, the quarters of the public works departments, and, in the winter season, the hotels.

There are a few interesting notes regarding public latrines. As flooring, railway cinders are used, and this is declared to be much better than cement. Sand is also advocated, but is said not to be so good. In Khartoum I do not think a sufficient supply of railway cinders could be obtained, and, both as regards this and sand, the carting away of the fouled floor and its replacement would entail considerable expense.

No water is used in cleaning the latrines, the seats being rubbed down with dry sand. I have not tried this procedure, but it would seem to have some advantages.

The use of lamps at night in the latrines is strongly advocated as a means of making them more popular and preventing natives going to earth in any convenient spot. This has everything to recommend it.

Hamilton, already quoted, finds that a mixture of one part kerosine, one part tar, and four parts mud mortar makes a good latrine floor. If desired, crude carbolic, under 4 per cent. strength, can be added as a deodorant and disinfectant.

Waste water

2. *Waste Water Collection and Disposal.*—The term "waste water" includes bath, kitchen, and scullery effluents, bedroom slops, urine, storm waters and the waste waters derived from mineral water factories, shop washings, and so on.

The question is a serious one, for as soon as an ample water supply is an accomplished fact this waste water will greatly increase in volume. In the case of the British Barracks, it is removed twice daily in Crowley carts and discharged upon the desert, about one and a half miles to the south of the town. In the case of the Gordon College, a system of surface irrigation has been devised, and this, on a less elaborate scale, is operative at the Grand Hotel, both of these buildings having extensive grounds under cultivation. Elsewhere, for the most part, waste water is simply thrown out upon the streets or into the yards. This is an insanitary proceeding and may at times give rise to danger. We know, for instance, that urine may contain the bacilli of typhoid fever, Malta fever and tuberculosis. Schemes have been proposed for dealing with the waste water by means of surface drainage, but the difficulties, owing to the lack of proper fall, appear to be insuperable. Where a large volume of waste water has to be dealt with it will be necessary to provide cemented, covered pits, and remove the contents by a cart to which a pump and hose are affixed. All this is very undesirable, for it is difficult to get a water-tight pit constructed, and such places tend to serve as mosquito breeding-places; but it appears unavoidable until a water-carriage system is installed. The water collected could be discharged into the septic tanks.

3. *Collection and Disposal of Refuse.* Refuse

The Sanitary Service is only responsible for the removal of refuse from the town and its final disposal. Metal dust-bins are provided for the reception of road sweepings. It is collected, usually along with a great quantity of sand, by the town carts, which bring it to the conservancy collecting station. There it is discharged into large trollies and drawn out to the trenching-ground, where a two-celled destructor of a simple pattern has been erected. The refuse is for the most part light, dry, and inoffensive, consisting of straw, stable debris, paper, rags, old tins and broken bottles. It does not yield a useful slag, but provides plenty of heat for the boilers. To prevent so much sand being collected, the carters have been supplied with hand riddles, but it is difficult to get them to use these as frequently as they should. Dead animals are removed beyond the confines of the town and left to the vultures, which speedily pick them clean. An effort is to be made to cremate these carcases in the destructor now that the latter possesses an additional cell.

Water Supply.—The whole question of the future water supply for Khartoum is still *sub judice*, and I have no desire here to enter into the realms of controversy. Hence this section will be dealt with very briefly. In the first place, we will consider the present system, and then deal with the proposed improved supply from a bacteriological standpoint. Dr. Beam deals with it from the chemical. At present, then, as in the past, the town mainly derives its water directly from the Blue Nile. This river varies greatly at different seasons of the year. In the summer and early autumn it is fully a quarter of a mile in width, possesses a rapid current and is laden with silt. Its waters are then turbid and carry a large quantity of suspended matter. In the winter and early spring it shrinks very considerably, so much so that its depth becomes insignificant and many sand banks appear. Of late years, during the months of April and May, more than half its bed has been dry. The current becomes sluggish, and this year the so-called "green water," due to the abundant growth of a species of Alga, Fig. 22, has made its appearance. The chemical composition of Blue Nile water has been the subject of study by Dr. Beam (*vide* Report of the Chemical Section, Second and Third Reports).

Water supply

Blue Nile water

Bacteriological examinations have been conducted in the course of the present year, samples being taken close to the bank and from the middle of the stream opposite the site of the water-works at Burrè, and also by Mr. Archibald from the middle of the river opposite the Gordon College. Unfortunately, some of the results were lost in the fire, and one cannot give full details. One knows, however, that in the month of January, 1907, the number of organisms in 1 c.c. of the water taken close to the bank above the town was between 300 and 400 (agar count at 37° C., 48 hours incubation), while in a sample taken from the centre of the stream at Burrè in February, 77 organisms were found per 1 c.c. In May, a sample taken from mid-stream, opposite the Gordon College, gave 84 organisms per 1 c.c. Water taken from near the bank contained excretal ("Flaginac"), *B. coli*, in 1 c.c., while this organism was present in 5 c.c. in water from mid-stream, but was not found in 0·02 c.c., 0·1 c.c. and 1 c.c. of such water. At present the water is collected anywhere along the banks. It is baled by the water porters into canvas sacks, carried by donkeys, and is then distributed throughout the town. Nearly every household possesses zeers, large earthenware filter jars, into which the water is put, and the clear filtrate is used for drinking and other domestic purposes.

Method of supply

Fig. 22.—Form of Alga causing "green water" in the Blue Nile

Water for the troops is collected at a special place above the town, and, as far as possible, the water porters are made to take their samples up-stream, but it is impossible to exercise any special control in this direction when some three miles of foreshore on each bank have to be watched, and the control has to be committed in large measure to the Egyptian police, who are practically useless for sanitary purposes. Care is taken to prevent water being taken from pools at low Nile.

The river water is very palatable, and as long as the river is not stagnant it does not, despite statements to the contrary, appear to be a cause of communicable disease, largely, I believe, because enteric fever is rare, because the bulk of water is very great, because saprophytic organisms successfully combat the pathogenic, and because most of those who drink unfiltered and unboiled Nile water are not very susceptible to such disease conditions.

At the same time, it is bacteriologically impure, and it is a very disquieting fact that the town has still to rely chiefly on a supply which is readily open to contamination in the presence of an epidemic of cholera, enteric fever or dysentery. Moreover, the method of supply leaves much to be desired, and would have been improved ere this, but that the new works were begun nearly four years ago, and one has lived in hopes of seeing the new supply supersede the old. So far these hopes have not been realised.

Shallow wells

Water is also obtained from the numerous shallow wells, but such water, which is always impure from a bacteriological and chemical standpoint, and is usually hard, is not generally employed for drinking purposes. It is used for washing, cooking, irrigating gardens and watering animals. It is sufficient to say that, as a rule, *B. coli* of a "flaginac and excretal" type is often present in so small a quantity as 0·02 c.c. In a few cases the drinking of such shallow well-water appears to have induced dysentery, and in one instance this was associated with the presence of *Bacillus pyocyaneus*. The relation of the level of the water in these wells to that of the Blue Nile is a very interesting subject, which is now being studied. Charts are being prepared by the Irrigation Department, and Mr. Drummond, of the Gordon College, has kindly collected some data as regards the village wells at Burrè. The work, however, is not yet complete, so that it is not desirable to tabulate it at present.

Deep wells at Burrè

The proposed supply is to be derived from a chain of seven deep wells sunk at Burrè; the one nearest the Nile being 30 feet from its southern bank. The deepest of these wells is 300 feet in depth, and they undoubtedly tap a deep water which Dr. Beam has shown contains considerable quantities of iron and manganese. The bores are protected down to a depth of 70 feet by iron tubes, but these tubes terminate, not in an impermeable bed of clay, but in porous sandstone. As Dr. Beam has entered somewhat fully into the matter in his Chemical Report there is no need for me to be discursive here, and one may at once proceed to a consideration of the results obtained in the bacteriological examination of the water from these wells. A sample taken on January 1st, 1908, after 48 hours' pumping from Well No. 3, the temperature of the water being 28° C., yielded 48 hours agar plates incubated at 37° C., which were uncountable even when only 0·2 c.c. of the water was tested. There were certainly over 2000 colonies per 1 c.c. and *B. coli* was present in 0·02 c.c. The organism differed only from "flaginac" *B. coli* in not producing gas in a lactose medium.

Bacteriological analysis of Burrè water supply

On January 11th, 1908, another sample was taken after prolonged and nearly continuous pumping for six days.

Result.—Agar count as above = 1,126 colonies per 1 c.c. *B. coli* ("flaginac") in 0·02 c.c.

It was evident that the water was contaminated, and an effort was made to secure a better sample from this well.

On January 19th, a test was made. The number of organisms per 1 c.c. had fallen to 218, but true "flaginac" *B. coli* was present in 1 c.c. of the water.

On February 23rd, a partial examination was made of the water (temperature=30° C.) from Wells 1, 2, 4, 5 and 6, after 72 hours' continuous pumping, and 328 colonies per 1 c.c. were found, and *B. coli* in 1 c.c. as before.

On March 1st, the water from the same wells was again sampled, after a prolonged pumping trial, and there proved to be 368 colonies present per 1 c.c., while, as usual, "flaginac" *B. coli* was found in 1 c.c. and larger quantities. It was not present in 0·02 c.c. or 0·1 c.c.

Bacillus enteritidis sporogenes was present in 500 c.c., but not in 1000 c.c. of the water. Streptococci were present in 0·1 c.c.

Enough has been said to show that the water at the time these tests were made was bacteriologically impure. It was, indeed, condemned without any hesitation. It remains to be seen what future examinations will reveal, but I have all along held that, topographically, the conditions are not satisfactory, and it is of special interest to note that a distinct ratio appears to exist between the number of organisms in the well-water and the number found in the Blue Nile. There are just about four times as many in the former as in the latter, while *B. coli* is found in 1 c.c. of the former and 5 c.c. of the latter. One is led to the conclusion that Blue Nile water is making its way into the unprotected bore-holes, and doubtless the increased temperature brings about a multiplication of the organisms. At the same time, one must not forget the presence of shallow, unprotected wells, and of an old native cemetery at no great distance, while a recent paper by Dawson[1] has pointed out that, in India, black clay soil may act as a culture medium instead of as a filter. Dawson's paper is very valuable in the light of what has been found at Khartoum, where the whole water question is on a very unsatisfactory basis. Personally, I am persuaded that we would be well advised to sink tube wells in the river sands, and so obtain a clear and practically inexhaustible supply which could be properly filtered under careful supervision, the filter action being controlled by frequent bacteriological tests. Certain it is that at present the Burrè deep well-water is quite unfit for consumption, while the presence of iron and manganese in it has resulted in the growth of *Crenothrix polyspora* in the pipes. Fortunately, the representations from the laboratories have been effectual in preventing this water being supplied to the town. Bacteriologically, many more examinations will have to be conducted throughout a whole year before our knowledge of the conditions can be considered complete. Space does not permit of any more extended

[1] Dawson, A. W. (January, 1907), "The Supply of Drinking Water in India, and its Connection with the Sub-soil Water." *Journal of the Royal Institute of Public Health.*

consideration of this all-important subject, but sufficient has been said to indicate how matters stand, and to point the lesson that it is essential, in considering a water supply, to carry out careful preliminary tests from an engineering, geological and sanitary standpoint before any scheme is embarked upon.

Aerated waters

Aerated Waters.—There are now no less than seven factories for their manufacture in Khartoum, and three at Khartoum North. The drinks chiefly supplied are soda-water (so-called), lemonade, ginger ale, orangeade and "roman," the last being a preparation flavoured with syrup of grenadillas. The colouring matter of orangeade consists of Orange B, which Weyl found to be slightly poisonous to dogs. I do not think, however, that the quantity found, even in many bottles of orangeade, could be pronounced injurious. At the present time, filtered river water is alone permitted to be used in the manufacture of aerated waters. The provision of a Doulton or Pasteur-Chamberland filter of sufficient capacity is insisted upon. Every factory has to be inspected by the Sanitary Inspector and Medical Officer of Health before it starts work; they are all frequently visited. It is, of course, impossible to make sure that the instructions given are always faithfully carried out, but as recently some evasion of the sanitary regulations was detected, samples are now seized for analysis whenever considered desirable, and steps will be taken to punish more severely than hitherto those who through carelessness or wilful negligence endanger the public health.

In a few of the factories the arrangements are very good, but, as a rule, the bottle-washing and cleaning could be improved by the introduction of up-to-date appliances, while improved apparatus for adding the flavouring agents are desirable. An insanitary procedure, once in vogue, was the use of old corks. These were collected from the streets, neighbourhood of cafés, etc., by boys and sold to the factories. After an example had been made of a few delinquents, this trade in old corks came to an end.

Ice

Ice.—The ice is supplied from a large factory at Burrè where a sulphuric acid machine is in use. The ice itself is made from condensed steam, and, so far as quality goes, leaves nothing to be desired. Steps were taken to improve the method of transport. No fault has been found with the storage methods in vogue, but the handling and distribution leave something to be desired. It is not easy in a country served by native labour to remedy completely such defects, but the Sanitary Inspectors pay attention to these points and issue a warning when necessary.

Milk, sources of supply

Milk.—The milk supply of the town is derived from two sources:—

1. From cows at the Government farm, which is under the control of the Director of Lands and Agriculture. This a limited and somewhat expensive supply, mainly intended for British residents. The milk, which is of good quality, is issued in proper bottles, and, as a rule, care is taken to see that it is in a cleanly condition. On one occasion only has it been necessary to make a complaint regarding the milk.

2. From goats and a few cows owned by villagers in the various "daims" to the south of the town. Some of this milk comes from villages six to eleven miles away. It is brought into Khartoum very early in the morning, being carried on the heads of women, who then go their rounds and supply their customers.

At an early date it was apparent that this system of milk supply was faulty in the extreme. In the first place, the women used earthenware pots (*burmas*) for the conveyance of the milk. These are to some extent porous, and, as a result, could not be properly cleaned. Than the walls of these vessels, no more favourite site for the multiplication of micro-organisms could well be imagined. The tops were uncovered, and dust had free access to the milk, or, if care was taken to prevent this, the means used consisted in stuffing a few rags—often filthy rags—into the mouth of the jar. It was found also that the vendors frequently washed their hands in the milk, while it was quite the custom to dilute it with

Faulty conditions

any water which was convenient. The filthy mixture, which at times was sold to an unsuspecting public, certainly did not deserve the name of milk. Measures were at once taken to control this trade. The women were all registered, proper milk-cans were supplied, and offenders were severely punished, though only after matters had been carefully explained to them, and when there could be no doubt as to their disobedience being wilful and not merely the result of ignorance. All this did some good, but it was not sufficient. The women cannot always be under observation, and they evade the by-laws. If the Egyptian policeman was of any use from a sanitary standpoint, the measures taken might suffice; but he is, as a rule, a monument of stupidity, so far as sanitary affairs are concerned, and often aids and abets the offender through the kindliness of his heart and the thickness of his head. The milk supply, then, is still of doubtful quality, and the method of employing calabashes as cups wherewith to measure it out does not improve it. Hitherto the staff of sanitary inspectors has been so small that it has not been possible to go further, but next year it is hoped to institute a reform.

Proposed remedy

The vendors will be made to bring the milk in properly covered cans to a central station. There the milk will be transferred to other cans owned by the Sanitary Service. Each can will be provided with a padlocked cover and with a tap for delivery. When filled the can will be locked so that milk can only be obtained from the tap. The inhabitants will be notified of the change, so that they have only themselves to blame if they do not see the milk directly supplied from the can. In the evening the cans will be returned to the station for cleansing purposes, and the women will be given the vessels, for milk transport, which in the meantime will have been properly cleaned. Whenever desired, samples of the milk will be taken for analysis before it is sent out to the consumers. This seems to me the best way of dealing with the difficulty. It is simple and should prove effective. I fear it can only be applied to Khartoum, at least at first. Later, if found to work well, I hope to introduce it at Khartoum North. It is only fair to add that, despite the faulty conditions which have obtained, there does not seem to have been much illness produced by the dirty and watered milk. The native baby is breast fed, and so, I think, for the most part are the Egyptian, Syrian, Greek and Italian infants. It is to these communities this milk is chiefly sold. In the summer of 1907 there was a considerable amount of infantile diarrhœa, however, and this may have been due to the faulty milk supply. Of course, one has to remember that, owing to the habits of the consumer, a good milk may quickly deteriorate after being supplied to them, owing to faulty storage and other causes. This, as mentioned in the Review Supplement, is specially apt to occur in the Tropics.

Milk and disease

Slaughter-house

Slaughter-house.—A new slaughter-house, built on the same lines as those in Egypt, was erected in 1906. So long as it is carefully looked after, and there is a sufficiency of labour and of water, no great fault can be found with it. If not properly managed it soon becomes a much greater nuisance than the primitive native slaughtering place, which consists of a yard with a few poles and trenches into which the blood is run and the offal is cast. This is the kind still in use at Khartoum North, and it is remarkable how sweet and clean it can be kept. In Khartoum the blood and sweepings pass into a cement tank, and are baled out into a Crowley cart, which also removes the offal and manure. The contents are dealt with at the sewage trenches, being in part pitted and in part spread out as a feast for the vultures, which make most efficient scavengers.

I believe the provision of lairs at the slaughter-house has tended to improve the quality of the meat, and efforts have been made to secure better apparatus for hanging the carcases, while the well has been covered, a pump supplied, and the water distributed by gravity from an iron and covered tank.

The inspection of meat is in the hands of the Veterinary Department.

Markets

Markets.—These are interesting places, and have undergone several changes of late years. Proper sheds have been built, the floor of the meat market has been cemented, and the butchers are required to supply zinc-covered tables. The latter are railed off, so the general public cannot sprawl over them and handle the meat, as was formerly the case. Dogs are now excluded, save when the Egyptian policeman fails to observe a hungry pariah prowling about under his very nose—too frequent an occurrence. To do him justice, when his attention is directed to the matter, he makes up for his negligence by the energy with which he expels the intruder.

Tripe and internal organs generally are sold in a special place. The filthy habit of inflating the lungs by blowing down the trachea was in vogue, but this practice has been stopped and bellows are provided for the purpose.

The fish market is provided with brick and cement slabs, but might be improved if money was forthcoming. The frying of fish is one of our few noxious industries. Still, being conducted in the open air, it causes very little nuisance.

The fowl market is not a cheerful spot, the birds being crowded into small wooden coops which are piled one on the top of the other. Fowls are treated with great cruelty in the East, and I think efforts should be made to improve their lot generally. Apart from the humanitarian point of view, it would pay to see that they are better looked after, and not carried about in bunches with their legs tied together and often left lying in the hot sun. The poor creatures must frequently perish for lack of water. Moreover, the methods of storage expose the fowls to the attacks of lice, mites and ticks. They often get into a miserable condition through the irritation and loss of blood produced by these parasites, while, as will be shown, spirochætosis is common amongst them. So is scaly leg, fowl diphtheria, and most of these avian diseases predisposed to by lack of care and cleanliness and by overcrowding.

If only funds were available, much might be done by erecting tick-proof fowl-houses and by aiding the vendors to improve their stock. As it is, no means are available for this purpose, which is one reason why chicken meat is often so tough and unsavoury in Khartoum.

The young pigeons suffer less, not being confined in the same way. Turkeys die of tuberculosis, pneumoconiosis, avian diphtheria, and several other complaints. I have known one succumb to a malignant tumour of the brain, a glio-sarcoma perforating the skull.

In the sûk, jerked meat (dried in the sun) is sold, so is fish—flesh, bone, and cartilage being all crushed up together till it is impossible to tell from mere inspection of what the mass consists. It is well cured and seems wholesome. The sale of partially dried and stinking animal intestines, beloved by the Sudanese, has been prohibited, though they would appear to be able to devour such abomination with impunity. Its very odour, however, constitutes a nuisance.

Cold storage

Cold storage would benefit the food supply in Khartoum, and so would careful attention to the rearing of fowls, and the improvement of breeds in cattle and sheep. Cold storage plants on the river steamers would enable venison, guinea fowl, fruit, and other delicacies to reach the Khartoum market, while refrigerators might also be useful on the trains running to and from Port Sudan.

Lastly, we proceed to discuss :—

Infectious diseases

Infectious Diseases.—It may be said at once that, considering its latitude, Khartoum is wonderfully free from communicable disease. Absolutely reliable statistics cannot be presented, although notification is in force, but each year we can gain a very fair idea of the extent to which infectious disease is present and in which forms it has existed. The following diseases are notifiable :—

Notifiable diseases

Anthrax, Beri-beri, Cerebro-spinal Fever, Chicken-pox, Cholera, Dengue, Diphtheria, Dysentery, Erysipelas, Filariasis, Glanders, Enteric Fever, Hydrophobia, Leishmaniosis

(Kala-azar), Leprosy, Malaria (locally acquired), Malta Fever, Measles, Plague, Pneumonia, Relapsing Fever, Smallpox, Trypanosomiasis, Typhus Fever, Whooping Cough.

Of these, the following have been present since 1904:—

Cerebro-spinal Fever (one case only until May and June of this year, when three cases occurred), Chicken-pox, Dengue (one case only—imported), Diphtheria, Dysentery, Erysipelas, Enteric Fever (rare, some cases amongst British troops), Hydrophobia (one case only), Leprosy, Malaria, Measles, Pneumonia, Smallpox (one case only), Trypanosomiasis (one case only, imported), Whooping Cough.

So much has been written about these diseases under their appropriate headings in the Review that little need here be said. The reason so many were made notifiable was to enable one to become acquainted with the forms of infectious disease which occurred.

As regards chicken-pox, I would point out the great desirability of checking this disease at first, whenever possible. Although rarely fatal, it causes some suffering and may entail much annoyance and some expense to the parents of patients, while it may also interfere with education. Furthermore, if chicken-pox be prevalent, initial cases of smallpox may easily be missed, and before things can be remedied an epidemic of variolā may lead one to regret that more rigid measures were not adopted in the case of varicella.

Dysentery in Khartoum

The question of dysentery requires more detailed consideration, for it is intimately concerned with the question of conservancy, and it is interesting to note the effect that the change in the latter has had upon the incidence of the former. Unfortunately, my detailed statistics on this point were destroyed by fire, but I take the following passages from the M. O. H. report for 1907. Amongst the Egyptian military there were 96 cases of dysentery notified from October, 1906, to the end of September, 1907. Of these, the great majority occurred amongst Egyptians, and it is quite certain that some of the cases notified were not dysentery at all. Bilharzial disease of the rectum is very apt to be mistaken for dysentery in the absence of microscopic examination of the fæces. Although there were four battalions in Khartoum, in addition to the Medical Corps, Works Department, and Stores and Supplies Department men; and only Artillery, small Railway and Stores Department staff, and one battalion in Khartoum North; no less than 49 of these 96 cases occurred in Khartoum North, where the old conservancy method still persisted. Moreover, when we come to consider the monthly incidence table, we find that, in the case of the Khartoum units, with the exception of the third battalion, which had four cases in August, most of the dysentery cases occurred prior to May, about which time the effect, if any, of the new system should have been becoming evident. Turning to the units at Khartoum North, we find that the largest number of cases amongst the Artillery occurred in July, and amongst the first battalion there were more cases in the summer than at other seasons. While these statistics are interesting, one must not make too much of them, because, after all, the number of cases is small, and doubtless other factors have to be taken into consideration. At the same time, I believe the faulty conservancy methods in vogue accounted in large measure for the small epidemic which occurred during the wet summer of 1906, when there were in all 134 cases—24 being civil, 107 Egyptian military, and 3 amongst the British regiments. Now the summer of 1907 was even wetter than that of 1906, but a radical change had been made in the collection and disposal of excreta, and during the year 1907 the total number of cases notified was 104, of which 6 were civil, 96 Egyptian military (already analysed), and 2 imported. During the present sanitary year, which ends in September, there had been notified, amongst a greatly increased population, up to the end of July, only 35 cases, of which 25 were civil, 8 were Egyptian military, and 2 were imported. My contention has always been that dysentery cases are most apt to crop up in places where there is much fouling of the soil, as in the neighbourhood of prisons and barracks; and it would certainly seem to be borne out by these figures, for a very marked improvement has taken place in the case of the Egyptian soldiery. Some of this, however, is due to greater care in diagnosis. It is noteworthy that in 1906 the outbreak terminated with the rains. I am of opinion that but little of the dysentery occurring in Khartoum is, strictly speaking, water-borne, but that it is chiefly due to the fouling of food and drink by infected dust, and this view is supported by the facts I have recorded, and by a consideration of other statistics available—for instance, the returns of monthly incidence of infectious disease. This is a question which also concerns enteric fever, and I pass to a brief consideration of that disease in its epidemiological aspects, as met with in Khartoum. My remarks regarding it apply more or less to dysentery as well.

Water supply and intestinal complaints

It has been stated that one need look no further than the present water supply of the town to account for the presence of cases of diarrhœa, dysentery and typhoid fever in it during 1907. Now it is easy to make such a statement, but quite another thing to prove it true, and if it is erroneous it is likely to do harm by limiting the sanitary outlook and tending to confine preventive measures to one source of evil. No one denies that the present water supply is a possible source of danger, but that it is an actual source remains to be proved. All the evidence goes to show that it is not the chief factor in causing these diseases, or, at least, that it has not been so in the past. Take the year in question—1907. We find there were 8 cases of dysentery amongst the civilian population, 2 of which were imported; and 15 cases of enteric fever, of which 5 acquired infection outside Khartoum. Thus, during one year, amongst a population of, say, 25,000 people, there were 6 cases of dysentery and 10 of enteric fever, and yet we are informed that the general water supply was to blame! Even supposing a good many cases were not notified at all, the numbers do not point to the drinking-water as a cause.

But it may be held that these cases should not be considered with reference to the whole population, but only with reference to those susceptible to attack by such diseases, presumably a population numbering about 3000. It is true this would be a fairer computation, at least as regards the 10 enteric cases, but we find that 2 of these occurred amongst soldiers at the British Barracks, where the drinking water, even though taken from the river above the town, is carefully boiled, while some of the other cases were natives, and so outside the 3000 susceptibles. As regards dysentery, it has yet to be proved that the native is not susceptible. The disease is not uncommon in Egypt, and Egyptian soldiers in the Sudan are certainly liable to be attacked. We know that the native of India suffers heavily from this disease and his surroundings and mode of life do not differ markedly from those of the native of the Sudan. As a matter of fact, most of our dysentery notifications refer to native cases, and, as I say, there is nothing to show that dysentery is chiefly water-borne, and much to indicate that, in the past, it has been due to infected dust gaining access to food and drink.

The Blue Nile supply and enteric fever

It is further asserted that it is the rise of the river, sweeping a foul foreshore, which is to blame. If this were so, one would expect that most of the cases would occur late in June and during July and August. As regards enteric fever, such has not been the case in the past. Taking the present sanitary year, we find that in November, December and July, respectively, one case occurred; there were two in May and four in June. As regards the cases in June, two of which at least acquired infection in May, there is little doubt that infection was derived from Nile water, for the river was very low, and in places practically stagnant. It was no longer self-purifying to any extent. In other years the greatest number of enteric cases has usually occurred in October, when the Nile is running full. Owing to the loss of my statistics, I am unable to present figures in detail, but the facts are as stated, and there is nothing to show that the river supply is the chief source of infection. At the same time, it should be abolished as soon as possible and a satisfactory supply substituted for it.

Taking the dysentery cases for the present sanitary year, it is instructive to find that they have been fairly equally distributed throughout the past ten months, the greatest number (four) in any one month occurring in December. Here, again, there is no evidence that the Nile water is markedly at fault, and the conditions which formerly in large manner determined both the presence and the monthly incidence of dysentery in Khartoum are now in part lacking. I refer, of course, to the fouling of the surface soil, and to the summer rains. There can be little doubt that, given dry conditions, even persistent fouling may produce but little evil results in the presence of a powerful and sterilising sun, and personally I believe that this partly explains why we do not have extensive outbreaks of epidemic disease when the Nile begins to rise. The filth and refuse which have accumulated on the sand-banks and foreshore, the deposit of which it is very difficult to prevent, has been practically sterilised by the intense heat and light or ever it is washed away by the rising river. As the fouling goes on daily, some of it, of course, if infected, must be in an infectious condition when carried down stream, but this state of things cannot be at all common, especially as regards enteric fever, for, as stated, this disease is rare in natives, and it is these who chiefly, under cover of night, use the dry river bed as a place of convenience.

Dysentery and Dust

With what has been said on *page* 73 we may conclude this consideration, remembering, however, that our efforts must be devoted to combating every faulty sanitary condition, and that general statements of the type indicated are to be carefully avoided, or, if made, to be adjudged at their proper value.

Disinfection

Disinfection.—The town possesses a Thresh "Emergency Disinfector," but the Sanitary Service has permission to employ the steam disinfector at the Military Hospital—a privilege of which it has several times availed itself. A Mackenzie spray has also been supplied, and it is intended to introduce the knapsack spray as modified by Robertson.

When fumigation is required, the formalin and permanganate method with preliminary moistening of the atmosphere, is employed. A cart for the conveyance of infected bedding, clothing, etc., is in use.

I believe the introduction of the portable Clayton system would be beneficial, especially as the river steamers could be fumigated, and mosquitoes thus destroyed. As a matter of fact, we have, as a rule, very little disinfection to perform.

Vital statistics

Vital Statistics.—Unfortunately, under present conditions, it is not possible to present statistics which can be considered absolutely reliable. Hence, it is better not to attempt the task. It is unfortunate, for nothing better indicates the sanitary growth of a town than a series of reliable statistics detailing birth rate, death rate, infantile mortality, and incidence of infectious disease. It is hoped ere long that we may be in a position to record these properly. At present I can only append the cases of infectious disease notified during the years 1904–1907 inclusive, and those for the months of the present sanitary year. Each sanitary year commences in October, and I can present the records of the past ten months.

Of late I have been classifying the returns under the three headings—Civil, Egyptian Military, British Barracks.

Considerations of space prohibit the insertion of the tables of monthly incidence which, except in a few instances—enteric, dysentery and diphtheria—are not of special interest.

1903–4

Infectious disease statistics

This was the first year during which notification was in force, and the returns were far from reliable. One would only note that 1 case of cerebro-spinal fever and 5 cases of diphtheria occurred.

1904–5

Chicken-pox, 19 (the majority occurring in the Civil Prisons at Khartoum and Khartoum North)

Diphtheria, 4	Hydrophobia, 1
Dysentery, 12	Measles, 50
Enteric Fever, 4	Smallpox, 2

The other notifiable diseases were not represented, with the exception of epidemic pneumonia, which scourged the Civil Prison, Khartoum, accounting for 41 cases and 10 deaths.

1905-6

	Civil	Egyptian Military	British Barracks	Imported	Total
Cerebro-spinal Fever	1	0	0	0	1
Chicken-pox	28	0	0	0	28
Diphtheria	0	0	2	0	2
Dysentery	24	107	2	1	134
Enteric Fever ...	6	4	1	7	18
Measles	25	1	0	0	26

A case of mumps was notified, 6 cases of pneumonia amongst the civil population, and 4 cases of scarlet fever at the British Barracks.

1906-7

	Civil	Egyptian Military	British Barracks	Imported	Total
Chicken-pox	1	0	0	0	1
Dengue	0	0	0	1	1
Dysentery	6	96	0	2	104
Enteric Fever ...	7	1	2	5	15
Erysipelas	2	0	0	0	2
Leprosy	0	1	0	0	1
Malaria	4	4	1	6	15
Measles	3	0	0	0	3
Whooping Cough ...	17	3	0	0	20

The other notifiable diseases were not represented.

1907-8 (ten months only)

	Civil	Egyptian Military	British Barracks	Imported	Total
Cerebro-spinal Fever	3	0	0	0	3
Chicken-pox	35	1	0	0	36
Diphtheria	2	0	0	0	2
Dysentery	25	8	0	0	35
Enteric Fever ...	10	2	0	0	12
Erysipelas	3	0	0	0	3
Leprosy	0	1	0	0	1
Malaria	2	1	0	0	3
Whooping Cough ...	1	0	0	0	1

The other notifiable diseases were not represented. It is not necessary to notify cases of imported malaria, though it is sometimes done. There were many such, but, as noted, only three cases locally acquired were notified.

The later tables give a very fair idea of the amount of infectious disease which was present in the town, but I do not think the returns will be quite satisfactory until we can pay those practitioners who are not in Government employ a notification fee, and so be in a position to inflict a penalty for non-notification. At present all that can be done is to provide these medical men with the necessary forms and with stamped, addressed envelopes.

This section concludes that portion of the Third Report for which I am personally responsible, and I would once again thank Dr. Beam for his photographic work, and the other members of the staff for their loyal assistance and support. As regard the sanitary work, Mr. Murray, the chief inspector, has done much to improve the general condition of the town, which, both from the sanitary and æsthetic standpoint, owes a very great deal to its first Governor, Colonel E. A. Stanton.

Sleeping Sickness and the Bahr-El-Ghazal Province

Extracts from Captain Howard Ensor's Report to the Sudan Sleeping Sickness Commission (April, 1908).

On behalf of the Sudan Sleeping Sickness Commission, Captain Howard Ensor, D.S.O., continued and extended the work begun by Major Dansey Browning. He traversed a large portion of the remote Bahr-El-Ghazal Province, and carried out important investigations often under great difficulties. The results of his expedition are incorporated in an interesting and useful report which, I understand, is to be printed and circulated. One need only, therefore, tabulate some of the facts of more general interest collected by Captain Ensor, while Mr. Archibald contributes a short paper on his Uganda experiences and observations.

Colonel G. Douglas Hunter, D.S.O., the President of the above-mentioned Commission, has kindly permitted me to reproduce the maps prepared by Captain Ensor, and the latter has been good enough to furnish me with information regarding his work.

He deals first with :—

A. The Tsetse Flies of the Bahr-El-Ghazal Province

Tsetse flies

Noting that only the two species *Glossina palpalis* and *Glossina morsitans* were found by him. Major Dansey Browning, however, discovered what Mr. Newstead believes to be a distinct variety of the latter species.

1. *Distribution.* The maps show the places where the presence of *G. palpalis* was noted, and Captain Ensor believes that this fly is to be found everywhere in the Bahr-El-Ghazal Province where the conditions necessary to its existence, *i.e.* deep shade near open water, are to be found. The palpalis areas exist for the most part along the banks of rivers, and in the province there are four riparian palpalis areas which begin at the Nile and Congo watershed, and extend to the north throughout nearly the whole extent of the province. Two of these, along the Sueh and Naam rivers respectively, are of the highest importance in connection with the question of the spread of sleeping sickness into the interior of the province, because the two principal roads connecting the southern districts with the centre of the province follow the courses of these rivers. The Arabic name of *G. palpalis* is given as "*Diban El Marad En Noom,*" the Fly of Sleeping Sickness, the local Zandeh name being "*N. Gunza.*"

G. morsitans is termed in Arabic "*Diban El Marad El Bohim,*" the Fly of the Cattle Disease, and locally in the Zandeh tongue is called "*Pay-a.*"

The more intelligent natives, therefore, clearly recognise the difference between the two species of tsetse fly.

G. morsitans is extremely common in most parts of the Bahr-El-Ghazal Province and is very troublesome. The localities in which it is known to exist are shown on the map. It is responsible for a heavy mortality amongst transport animals working along the roads from M'volo to Meridi, Meridi to the Bassumboru River, and from Khojali to Wau.

2. *Habits.* (i) Of *G. palpalis.* It exists almost exclusively in the immediate vicinity of the open water of rivers and pools, and the shade afforded by large trees is, according to Captain Ensor, absolutely essential. He has never found the fly along the banks of water-courses destitute of trees, even though thick scrub and long grass, affording considerable shade, may be present.

Glossina palpalis

G. palpalis is never found where the papyrus swamps prevail.

This is due in part to the absence of foreshore and of shade, and more particularly to the absence of dry ground in such places, for Captain Ensor has noticed that the fly, when

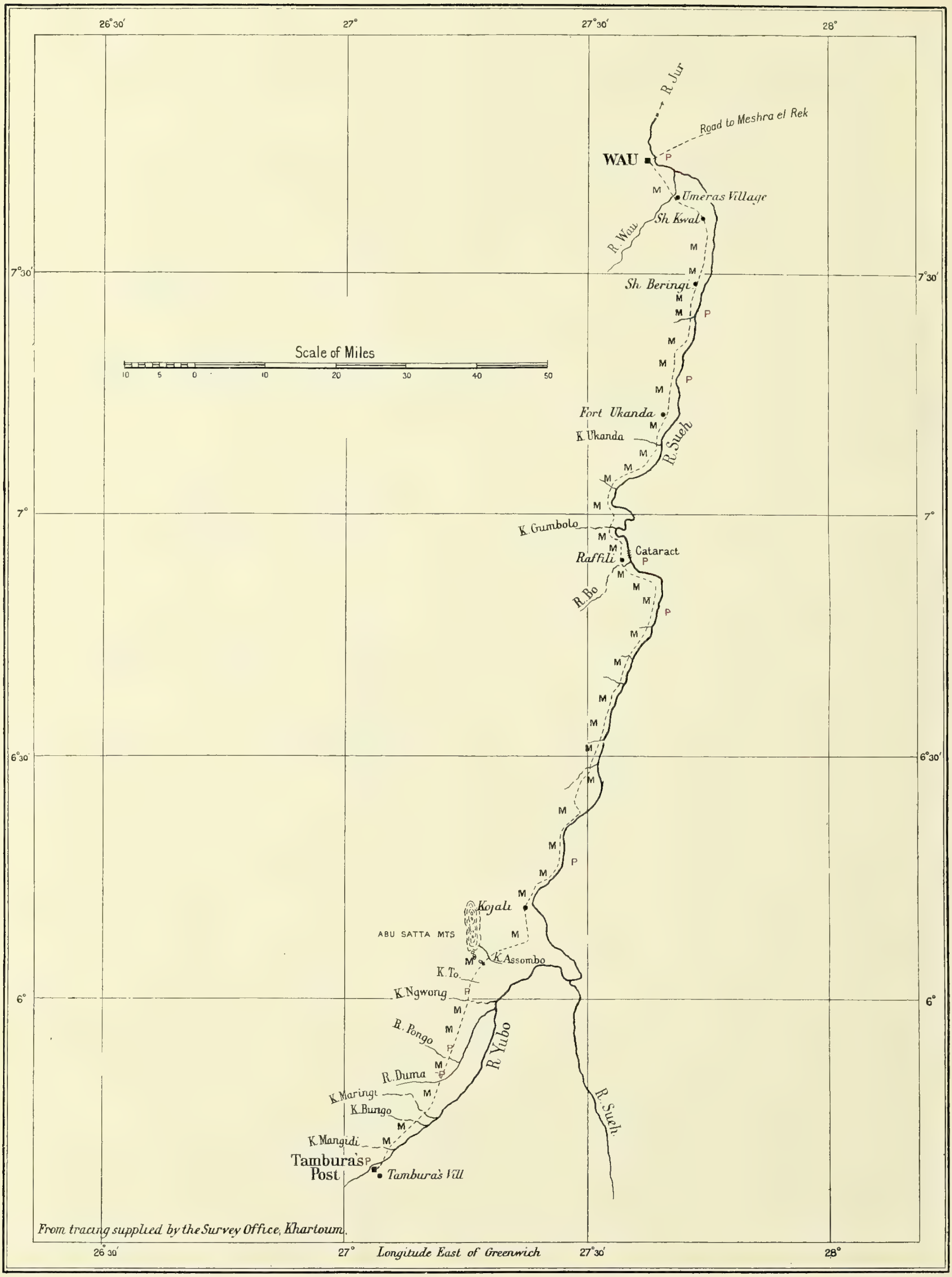


FIG. 23.—MAP OF ROAD FROM TAMBURA'S POST TO WAU

Reduced from a Map by H. ENSOR, CAPT. R.A.M.C., 1908

Places discovered to harbour *Glossina palpalis* marked with P

,, ,, ,, *Glossina morsitans* marked with M at rest, usually remains on the earth hidden from view by the leaves of any low-growing form of vegetation or by fallen leaves, while Bagshawe, in Uganda, has shown that dry earth is necessary for pupation. The fly appears to object to wind almost as much as to direct sunlight. To determine its presence in any locality it is necessary to sit down quietly in the deepest shade available and in a sheltered spot near the margin of the open water of a stream or pool, and to wait there patiently for at least half-an-hour before one can say with any degree of certainty that it is absent. The fly is difficult to catch and is most easily taken with a net when settling on the body of a native. To one with sufficient experience it can be identified, without actually catching a specimen, by the peculiar buzzing noise it makes when flying, and by the quick darting way in which it flits from place to place. *G. palpalis* is never very persistent in its attempts to obtain blood and will disappear after a few unsuccessful attempts have been made to capture it, thus differing very markedly from *G. morsitans*. The flies can be driven from shelter by disturbing scrub and fallen leaves with a long cane. When so disturbed they may attempt to settle and feed. They can, and often do, bite through clothing, but the latter, especially when of a white colour, certainly affords great protection. *Glossina palpalis*

G. palpalis appears to feed in the dry season most freely between the hours of 8 a.m. and 11 a.m., and is not, as a rule, much in evidence after these hours. This is possibly due to the fact that, at this season, a strong wind sets in daily about 11 a.m. and continues blowing until late in the afternoon. In the rainy season, if the day is rainy or dull, the flies do not appear to feed at all. If such a day clears up in the afternoon they may become active. If, at this season, the day be fine with a bright, hot sun and little or no wind, the fly feeds as in the dry season, between 8 a.m. and 11 a.m. At any time of the year there is very little danger of being bitten after 5 p.m. *G. palpalis* is much more numerous during the rainy season.

(ii) Of *G. morsitans*. This species seems to feed most freely from immediately after sunrise until about 11 a.m., becoming troublesome again about 4 p.m., and continuing to annoy both man and beast until the last ray of light has died out of the sky. It is exceedingly greedy of blood, and appears, when feeding, to be quite indifferent to the chances of destruction. It is often seen in large numbers, miles distant from the nearest stream or pool, but at the same time is extremely numerous near rivers. The latter fact probably depends on the presence of big game which attracts the flies to these localities. *G. morsitans* bites freely in dull and rainy weather, and is most numerous after the first rains of the season have set in. *Glossina morsitans*

3. *Food supply of G. palpalis.* Captain Ensor notes that, in the southern part of the Bahr-El-Ghazal Province, the rivers are not sufficiently large to harbour many crocodiles and hippopotami. In this region, apart from man and big game, aquatic birds probably furnish it with its meals of blood.

4. *Conditions influencing the range of G. palpalis.* Apart from what has been already stated, Captain Ensor mentions an interesting observation to the effect that the two species of *Glossina* appear to possess what he terms "definite spheres of influence" and never encroach upon each other's hunting grounds. He adduces evidence in confirmation of this statement, and says that, in their enthusiasm for blood-sucking, flies of the *G. morsitans* species will often follow one into a palpalis area, but that then they almost invariably disappear in a minute or two, their place being taken by hungry specimens of *G. palpalis*.

The normal range of the latter in the absence of *G. morsitans* he places at probably not more than ten or twenty yards from the open water which they haunt. He further states that solitary specimens of *G. palpalis* are sometimes met with in houses situated long distances from the nearest palpalis area and surrounded by a zone of cleared ground. The presence of these flies in such places should, perhaps, be regarded as accidental, and the flies seen have probably developed from pupæ which may have been carried up in the roots of grass used for repairing the roofs of houses, or brought up from a palpalis area in some other way.

B. The Existence, or otherwise, of Sleeping Sickness in the Bahr-El-Ghazal Province

Gland puncture

Captain Ensor's investigations extended over a period of eleven months and he examined over 4000 natives living in the districts adjacent to the Congo Free State and French Congo frontiers. Of these only nine were found to be suffering from a suspicious enlargement of cervical glands. Puncture was performed in four of these cases with negative results. He notes the presence of a slight enlargement of cervical glands in natives due to the irritation of pediculi.

Blood examinations

Blood examinations were conducted and careful enquiries made amongst chiefs and others. It was found that cases of sleeping sickness had occurred at the Sudan posts, occupied until recently by Congolese troops, and Captain Ensor believes that it is only too probable that some of our natives have acquired infection. At the same time he concludes by saying that the question as to whether sleeping sickness exists at the present time in the Bahr-El-Ghazal cannot be answered either in the affirmative or in the negative.

C. The Probability, or otherwise, of Sleeping Sickness becoming prevalent in the Bahr-El-Ghazal Province

Captain Ensor believes the disease will probably be introduced from the Congo Free State and not from the French Congo or the Lado Enclave.

Local conditions

He points out that there is a wide tract of uninhabited country between the latter and the Bahr-El-Ghazal, while, as regards the French Congo frontier, the tribes are still independent and probably limit all intercourse with their neighbours to occasional raids upon them.

On the other hand, inter-tribal intercourse between the southern Bahr-El-Ghazal and the Congo Free State is common, and has also developed in the Bahr-El-Ghazal owing to the more settled conditions which now prevail and the forward march of civilisation. He notes that there is no natural barrier and confirms the view I advanced in the Second Report of these laboratories.

D. Preventive Measures

Preventive measures

Captain Ensor concludes with a valuable section on this important subject. As the measures advocated are for the most part those in vogue in Uganda and elsewhere, one need only mention his suggestion to instruct the chiefs and sultans in the southern parts of the province and to pay them yearly subsidies on condition that they keep the watering places near their villages free from trees and scrub, and that they immediately report all suspicious cases to the nearest Government official.

Regulations for carriers are put forward and the building of rest-houses in appropriate situations is advocated. The abandonment of certain posts is recommended, and the appointment of a British Medical Officer in the Southern Bahr-El-Ghazal, to superintend operations, is strongly urged. Altogether, there can be no doubt that Captain Ensor's report will prove most useful to those responsible for safe-guarding the province from the invasion and spread of a justly dreaded disease.

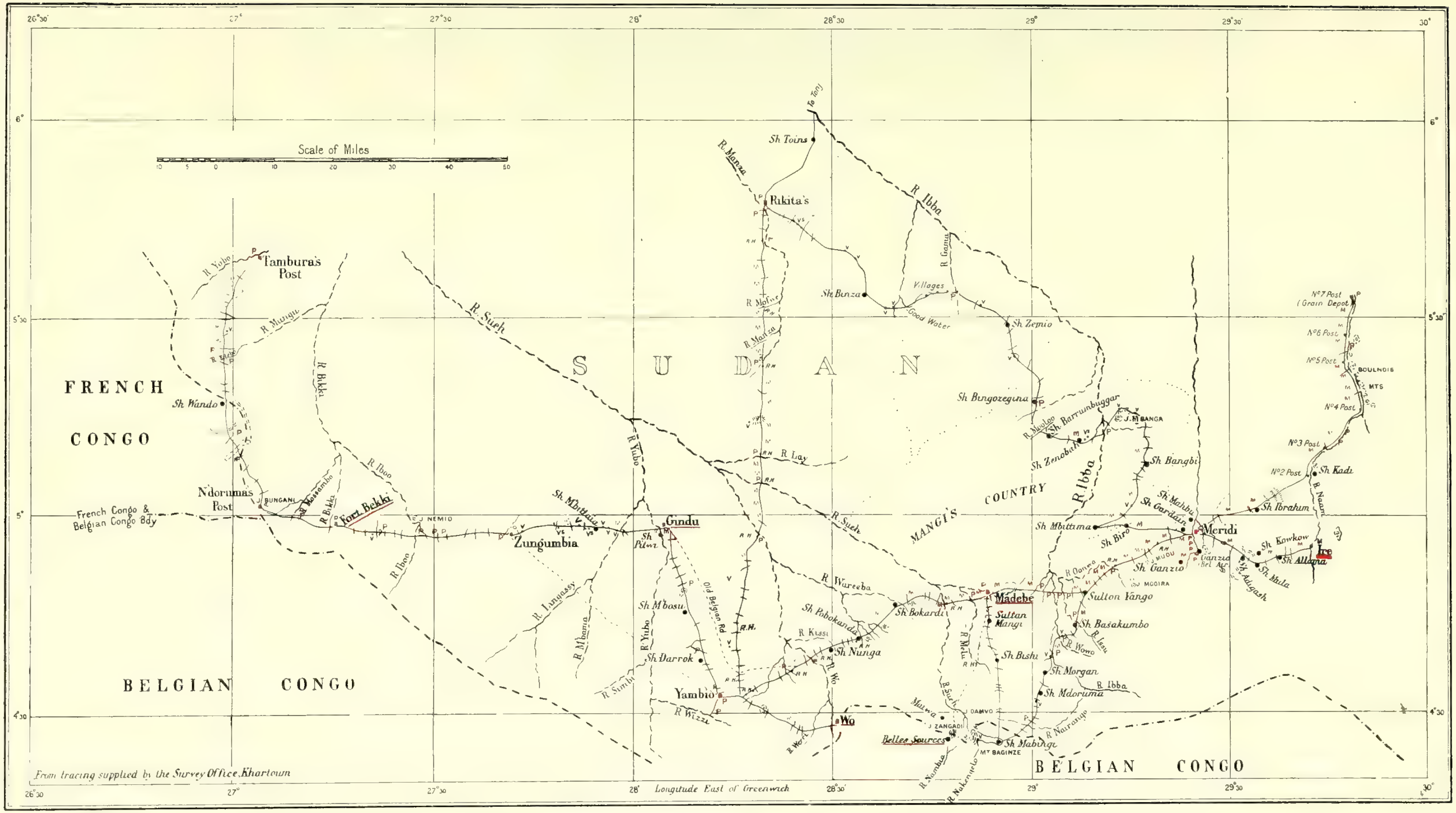


FIG. 24.—MAP OF SOUTH-WEST BAHR-EL-GHAZAL—*Reduced from a Map by* H. ENSOR, CAPT. R.A.M.C., 1908

The route taken by Capt. Ensor during journeys of investigation is indicated
Areas where *Glossina palpalis* has been found are marked P
Areas where *Glossina morsitans* has been found are marked M
Stations formerly occupied by Congolese Troops are underlined ——
Stations occupied by troops or police are shown thus ■
Tribal boundaries are shown thus .... the Sheik's village and name inserted

ADDITIONAL NOTES BY R. G. ARCHIBALD, M.B., R.A.M.C., attached Egyptian Army
Fellow of the Society of Tropical Medicine and Hygiene
Pathologist and Assistant Bacteriologist, Wellcome Research Laboratories

Captain Ensor's interesting and instructive paper contains valuable recommendations as to the measures to be adopted in preventing and limiting the very possible spread of sleeping sickness into the Sudan. Many interesting points also are brought to notice as regards the distribution and habits of the *Glossinæ*. At Dr. Balfour's request, I am appending a few comparative notes with regard to the habits of the *Glossinæ* in Uganda, and a few notes on sleeping sickness in that Protectorate.

Glossina palpalis in Uganda

My observations on the *Glossina palpalis* fly, *in natura*, have not been very extensive and are chiefly confined to this species as met with near Butiaba on Lake Albert, and at odd intervals while on trek from that place to Gondokoro. In Uganda, as in the Bahr-El-Ghazal, the essential conditions for a typical fly area are more or less open water with adjacent and overhanging shade, the fly having a selective preference for the shade of ambatch trees. The flies certainly were most active during bright sunlight, especially between the hours of 10 and 4, but no period of the day was entirely free from them. They seemed entirely to disappear when a high wind arose, especially if it were accompanied by rain. The greatest distance the fly was found from water was, roughly speaking, about 250 yards.

Two of the swamp rivers examined for the presence of *G. palpalis* gave negative results.

Examination of most of the flies that were caught revealed the fact that the male flies were far in excess of the female ones. Whether this was due to the fact that at some seasons of the year the male element predominates to a greater extent than the female, it is difficult to say. It is probable that the *G. palpalis* increases in number at certain times of the year while it almost disappears at others; this may account for the discrepancies which sometimes occur in the mapping out of the fly areas.

Clothing

Clothing is not an absolute protection against the attacks of the fly, which seems to have a special *penchant* for dark clothes and dark skin. It is a decided advantage, therefore, to have a native boy with one when studying the *Glossinæ*. When in the Nile districts of Uganda a search for *G. palpalis* on the shore gave negative results; they were found in fair numbers when shaping a course and paddling by the side of the trees on the river bank. Flies were not found where the river bank contained no trees or bush.

It is well known that wherever sleeping sickness has been found, its area of distribution has closely followed that of the *G. palpalis*, and the inference to be drawn from this appears to be fairly conclusive, *i.e.* that this is the species of fly which transmits the parasite of sleeping sickness. Experimental evidence has shown that the *Trypanosoma gambiense* can also be transmitted by the *Glossina fusca*, but whether the latter is not simply an accidental carrier remains to be determined. It may not, however, be of much practical importance as regards the introduction of sleeping sickness into the Sudan, as up to the present *G. fusca* has not been found in the Bahr-El-Ghazal.

Glossina palpalis only one factor

That there appears to be another factor concerned other than the *G. palpalis* in the transmission of *T. gambiense* receives some support from the fact that the Liverpool Expedition, in certain parts of the Congo Free State, found sleeping sickness widely prevalent while *G. palpalis* was only present in very small numbers.

My experience in connection with the difficulty of finding the pupa of *G. palpalis* coincides with that of Captain Ensor, a search for this pupa in thickly infected fly areas always giving a negative result. As regards preventive precautionary methods, Captain Ensor lays great stress upon the clearing of trees, bushes and grass surrounding all places where drinking-water is obtained. This wholesale clearing will, however, require to be maintained and it would be advisable that such cleared areas be used for the purpose of planting potatoes or even citronella grass. In Entebbe, the cleared areas on the foreshore of Lake Victoria have been planted with citronella grass with markedly beneficial results.

Planting of cleared areas

The process of clearing these infected fly areas will be attended with more or less danger to the natives employed for this purpose. This danger undoubtedly occurred in the clearing operations in Uganda, natives acquiring sleeping sickness from the bites of infected flies. It would be interesting to observe whether some means could be adopted to overcome this danger of being infected while clearing a fly-infected area. The natives employed might have their skins covered over with some form of oil or ointment, containing a powerful deodorant which would act as a deterrent to the attacks of the fly. This is a line of research which appears not to have occupied sufficiently the minds of those engaged in sleeping sickness investigations. If such a deodorant was found successful in warding off the attacks of the fly, its universal use by the natives would certainly tend to diminish sleeping sickness without interfering with the trade of the country.

As regards the important question of the diagnosis of sleeping sickness in its early stage, *i.e.* before the somnolent stage has been reached, my experience of gland puncture performed in several hundred natives, goes far to show that it is not by any means a reliable one, and I would suggest that all medical officers, engaged in sleeping sickness investigations, should be provided with a centrifuge, and all doubtful cases should have one cubic centimetre of the blood removed into a test-tube containing a 1 per cent. sodium citrate solution, the mixture centrifuged for ten minutes, and the superficial layer of the blood examined for the presence of trypanosomes. On several occasions Koch's method of examining the blood for trypanosomes was employed by me, but without success. This may have been due to some error in my technique. In Busoga, where filariasis is more or less omnipresent, mere palpitation of the gland substance was not sufficient for a diagnosis, and frequently on gland puncture typanosomes and filaria were found co-existing in the same gland juice.

Several cases which one examined in Uganda showed clinical signs and symptoms of the disease, and yet no trypanosomes were found on gland puncture and *vice versa.* It is hardly necessary to state that all such cases were treated as cases of sleeping sickness. Observations have shown that the *G. palpalis* is more or less omnivorous as regards vertebrate blood, and, as a further means of inhibiting the increase of the fly, all animals which offer the fly a means of sustenance should be destroyed. Another means of compassing fly destruction would be the importation of some bird or insect that would feed upon the tsetse. Such remains to be found.

As regards the medicinal treatment of sleeping sickness, atoxyl as a curative agent, in my hands, proved a failure. Cases that looked at first promising invariably relapsed. One notable feature of the action of this drug was its effect on the enlarged lymphatic glands, which appeared to undergo fibrous atrophy, and thus, directly or indirectly, the drug eliminated the trypanosomes out of the gland substance. They persisted, however, in the circulating blood. Used in combination with mercury, atoxyl gave disappointing results. One other medicinal agent, tartarated antimony, was used without success, but it scarcely had sufficient trial to warrant its condemnation. It was a melancholy fact that out of several hundred cases under treatment not a single cure resulted. It must be mentioned, however, that one was contending, not only against the effects of sleeping sickness, but those of famine also, and the combination went far to produce such discouraging results.

Medicinal treatment

In spite of the accounts by other observers of the effects of drugs as curative agents in this disease, judging from results, one is led to the conclusion that serum-therapy should be given a more extended trial in connection with the investigations for the discovery of a curative agent in sleeping sickness.

Serum-therapy

Kala-azar in the Anglo-Egyptian Sudan

BY

S. Lyle Cummins, M.B., B.Ch., B.A.O., R.U.I., R.A.M.C.

Historical

Kala-azar has been known to exist in North Africa since Laveran described a case from Tunis[1] in 1904. In the same year Dr. Sheffield Neave[2] proved its existence in the Anglo-Egyptian Sudan, reporting the discovery of the Leishman-Donovan body in the spleen of a Sudanese boy, under treatment in Omdurman Hospital.

In August, 1904, Dr. L. Phillips[3] called attention to certain cases observed in Kasr-el-Ainey Hospital, which he considered to be kala-azar. Two of them had contracted their illness in Arabia, while two would appear to have acquired it in Egypt.

In 1906, Captain R. B. Black reported a case of splenomegaly with continued fever, from a village near the River Dinder; stating that it seemed to him to resemble kala-azar. Being without microscopic appliances of any kind, he was unable to settle the diagnosis. This case gains importance owing to the subsequent discovery of the disease in this neighbourhood.

First case of present series

The series of cases which are dealt with in the present article began with the post mortem discovery of the Leishman-Donovan body in the spleen of an Egyptian soldier, dying of a disease, diagnosed "malaria," in Abbassieh Hospital. Colonel Leishman, to whom I submitted my specimens, to put the matter beyond doubt, very kindly examined them and confirmed my observation. A short note on this case and certain others appeared in the *Journal of the Royal Army Medical Corps*[4] of February 1st, 1908. Details of the cases mentioned therein form part of this article, but I venture to recapitulate the main facts.

The illness was proved to have commenced at Senga, on the Blue Nile. Enquiries were instituted as to the presence or absence of cases resembling kala-azar in the man's own Egyptian village; a medical officer of the Sanitary Department being sent for this purpose through the kindness of Sir Horace Pinching, K.C.M.G., at that time Director-General of the Egyptian Sanitary Department. No such cases were found, and it was concluded that the disease must have been contracted where it commenced, at Singa.

All Egyptian soldiers who had lived in the barracks with the man, while at Senga, were now examined. They were found to be in good health, with one exception. This case was under treatment for "malaria" in Khartoum Hospital. Captain F. F. Carroll at once carried out splenic puncture, and proved the case to be one of kala-azar. Within a short time another Egyptian soldier arrived from Kassala, and was found to be suffering from the same disease. His illness was traced to Mafaza, on the Rahad, a tributary of the Blue Nile. Enquiries were at once instituted, through the authorities of the Kassala and Blue Nile districts, with the following results:—Captain R. B. Black reported two suspicious cases in Arab policemen on the Blue Nile. Specimens were sent for examination to the Gordon College, and Dr. Andrew Balfour confirmed the diagnosis in both cases.

Mafaza an apparent centre of disease

Both these men were found to have contracted the disease during a visit to Mafaza.

A third Arab policeman died in the Southern Sennar district; the description of his illness, as given by the medical officer who attended him, making it almost certain that he too died of kala-azar. *He had come from Senga*, and reported sick shortly after reaching

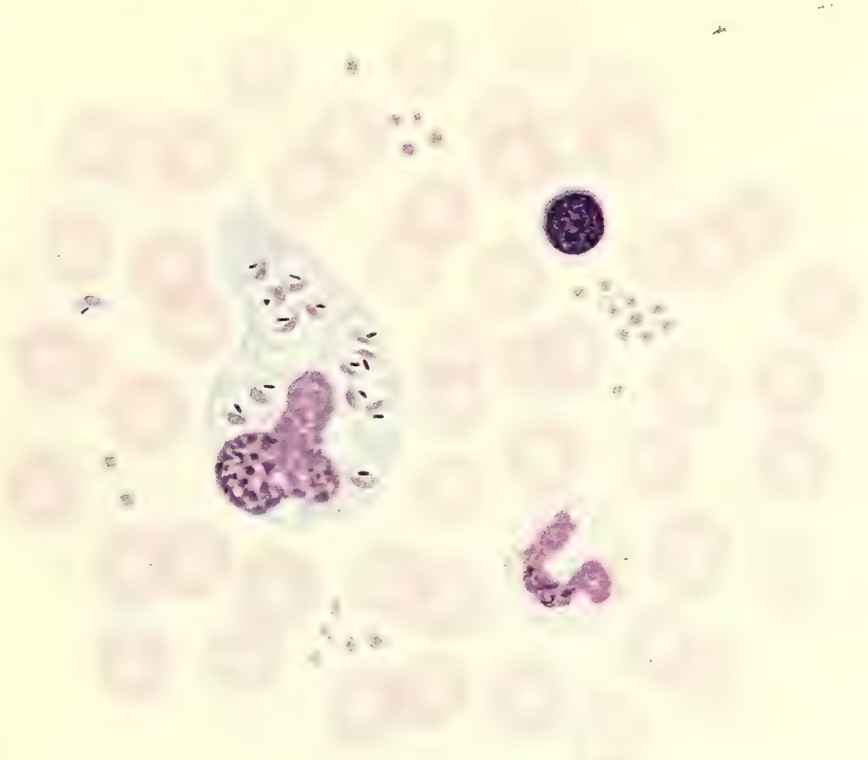
[1] Laveran, A. *Bulletin de l'Académie de Médecine*, March 23rd, 1904.

[2] Neave, Sheffield. *British Medical Journal*, May 28th, 1908.

[3] Phillips, Llewellyn. *Journal of Tropical Medicine*, August 1st, 1904.

[4] Cummins, S. L. *Journal of the Royal Army Medical Corps*, February, 1908.

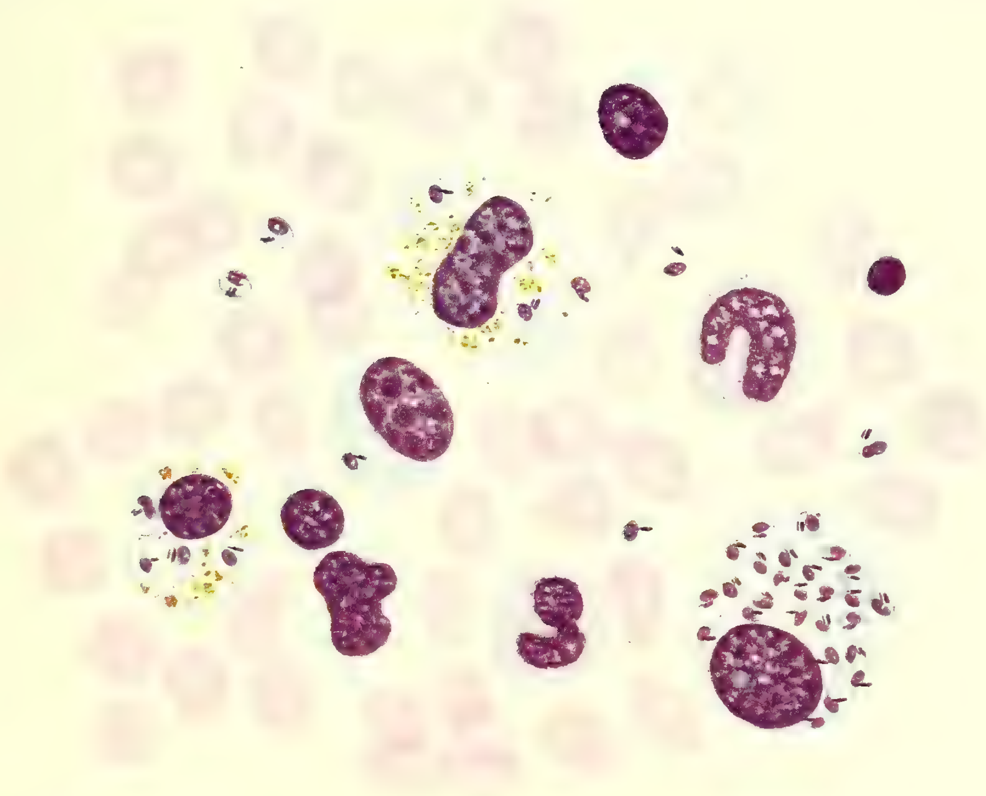
PLATE VIII



R. D. Muir

Kala-azar. Film from spleen. Case B

Leishman Stain × 1000 *diam.*



R. D. Muir

Kala-azar. Scraping from spleen. Case A

The Leishman-Donovan bodies are seen free and in the large mononuclears

Leishman Stain × 1000 *diam.*

Kaili, in Southern Sennar. No microscopic examination was possible in his case, owing to lack of appliances.

At about the same time, Dr. MacTier Pirrie, of the Gordon College, who had contracted a chronic fever while working in Southern Sennar, was found to be suffering from kala-azar by Dr. Gulland, of Edinburgh, and Major Marshall, I.M.S., through whose kindness I am able to append short notes of the case, which has been more fully reported elsewhere by them.[1]

Previous to receiving my communication, Captain L. Bousfield had suspected two cases, coming to his notice at Kassala, to be kala-azar; and he was shortly able to confirm his suspicion by finding the Leishman-Donovan bodies in the splenic blood. He at once set to work to investigate the disease in Kassala district, the results of his investigation being appended in a separate report (*see page* 107).

I will now proceed to discuss, as briefly as possible, some of the points which appear to me to merit attention in the series of cases under discussion.

DISTRIBUTION. With a single exception all the cases hitherto described in the Sudan have arisen in the vicinity of the Abyssinian frontier, or on the Blue Nile and its tributaries—rivers which rise in Abyssinia. It is possible that other cases exist in other parts of the Sudan, in view of the presence of the disease along the North African coast; but it is remarkable that none have hitherto been described. The sudden discovery of a considerable number of cases, all traced to the Abyssinian border or its vicinity, gives colour to the suggestion that the Sudan owes this disease to cases imported from Abyssinia. The high proportion of cases actually occurring among Abyssinians, taken in conjunction with the recent increase in trade and communication between that country and the Sudan, strengthens this probability, while the very slow growth of this communication during the early days of the Anglo-Egyptian regime may perhaps account for the previous rarity of the disease in the Sudan.

Distribution of kala-azar in the Sudan

Unless this theory is groundless, a considerable increase of the disease in the Sudan may be anticipated in the future.

The work of Major Leonard Rogers, I.M.S., and Captain Patton, I.M.S., goes far to demonstrate that the bed-bug is the agent by which kala-azar is transmitted from man to man. These insects are very common, both in the Sudan and Egypt, so that, given a certain number of imported cases suffering from the disease, there would seem to be a decided danger of its spreading in both countries.

With the exception of those described by Dr. L. Phillips, no cases have come to light in Egypt, although this country has been the field of investigation by many pathologists for many years; so there seems no doubt that it is extremely rare. This question will be dealt with more fully under the heading of Differential Diagnosis. I am permitted, through the kindness of Dr. Bitter, Pathologist to the Egyptian Sanitary Department, to refer to his recent observation of Leishman-Donovan bodies in a case of chronic ulcers in an Egyptian, which he intends to report elsewhere. This discovery is in line with the finding of these bodies in "Delhi Sore," and the accepted opinion would appear to be, that the organism producing these cutaneous lesions, though morphologically similar to that of kala-azar, is essentially different in nature; so that Dr. Bitter's discovery does not demonstrate the presence of kala-azar in Egypt.

Its rarity in Egypt

HOUSE INFECTION. I have not had an opportunity of going into the question of house infection on the spot, but the matter is discussed by Captain L. Bousfield in his paper.

House infection

The two cases in Egyptian soldiers from Senga, arose in men occupying the same

[1] *Lancet*, August 15th, 1908.

barracks, but apparently no further cases occurred among the remaining twenty soldiers of the Works Department living in this building.

A much more interesting and significant series is as follows:—

Detail of cases

1. Nafr. Mohd. Ibrahim Osman, Medical Corps, while stationed at Mafaza, lived in a grass hut which formed part of the "Police Huts" in the Zaptea Compound. He fell sick in July, 1906, and was relieved some time afterwards, leaving for Kassala in November or December, 1906.

2. Two Arab policemen, from the Blue Nile district, lived in Mafaza during May, 1907, presumably occupying the police huts. Both these men subsequently died of kala-azar.

3. An Arab policeman, from Kassala, Idris Adam, had lived in the Mafaza police huts from January, 1907, to January, 1908. He died of kala-azar in Kassala.

4. It should be noted also that a Wakil Ombashi, of the Medical Corps (Case II., Bousfield) passed three days at Mafaza in May, 1907, and is stated to have lived with the resident Medical Corps Tumergi, who, no doubt, occupied the same police hut as that of his predecessor, Ibrahim Osman. This Wakil Ombashi was found to be suffering from kala-azar in 1907; and, in my opinion, contracted the disease at Mafaza. In view of the present ignorance of the life-history of the Leishman-Donovan body, it is impossible to calculate the probability of a house remaining infected, or to judge how long the infection may last.

Dogs and kala-azar

Assuming the bed-bug to be the alternative host, it is possible that the infectivity may last through more than one generation, as occurs with the spirillum of Relapsing Fever.[1] Or, on the other hand, the observation of M. Nicolle,[2] that dogs are subject to the disease, taken with the domestic habits of these animals, may, perhaps, explain the occurrence of a series of cases, arising at long intervals, in the same building.

At any rate, the police huts at Mafaza would seem to have a fair claim to be considered infected during 1906–1907.

Bed-bugs, sent for classification to the Gordon College from the districts where kala-azar has occurred, are reported to be, in all probability, the *Cimex lectularius*.

The question of diagnosis

DIAGNOSIS. The disease has been so ably described,[3] that it is superfluous to repeat the points which enable a diagnosis to be made; but the following brief description may assist laymen to recognise cases in their districts:—

Kala-azar is a continuous fever, sometimes lasting for many months, accompanied by enlargement of the spleen and liver, and, finally, by great loss of strength. The feet and legs often swell, and the skin of the face may show dark pigmentation. It is resistant to quinine, and has a much greater tendency to kill its victim than has chronic malaria.

Any cases found to resemble the above should be suspected and the nearest doctor informed.

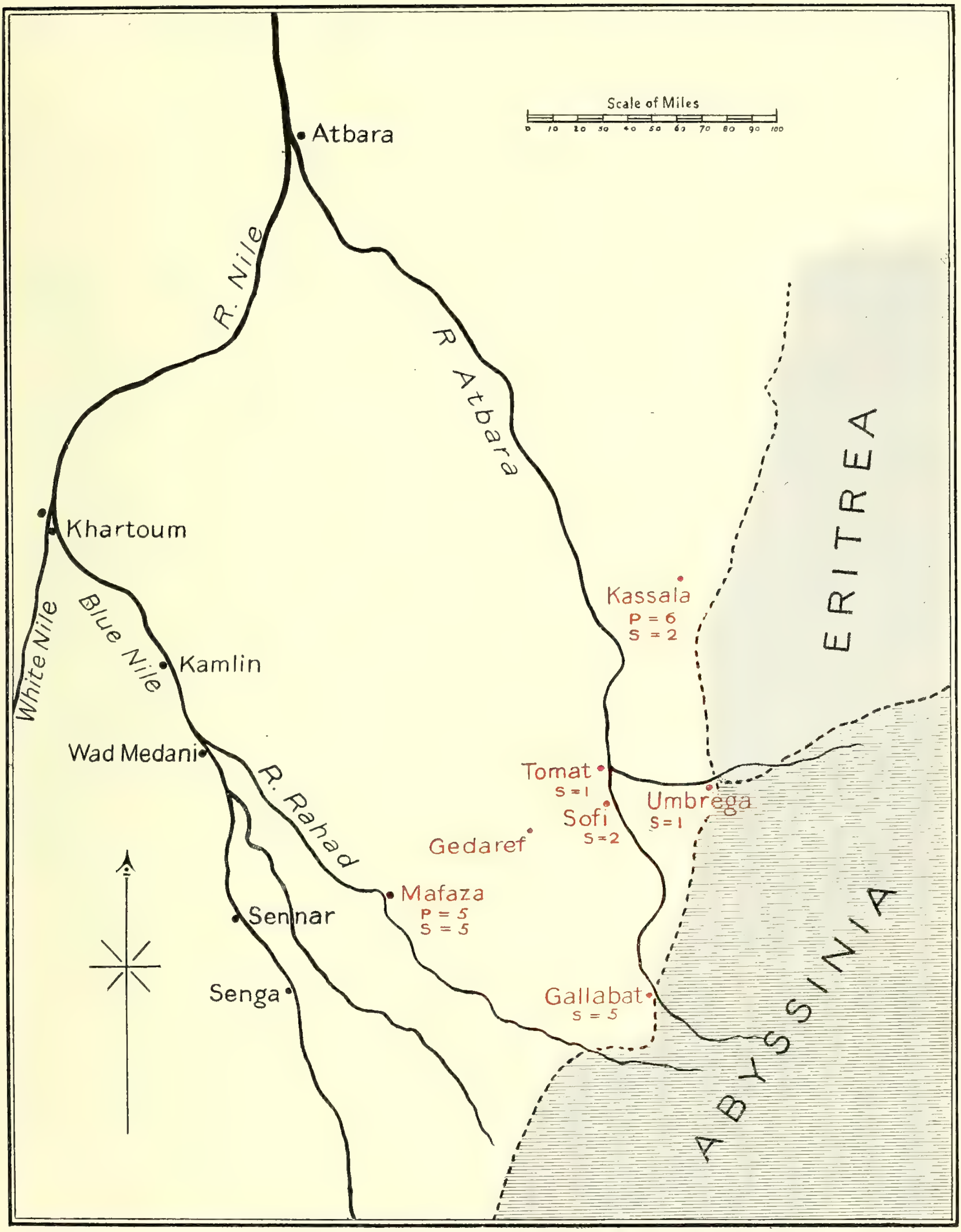
Frequent paucity of the parasite

Of course, to the doctor no case can be considered as definitely diagnosed until the Leishman-Donovan body has been found; but this leads me to a point, brought out clearly by the appended cases, that the failure to find the parasite, even on several attempts, does not finally exclude the disease. In some of the cases recorded, the parasites have been most difficult to find. In this connection, I may say that I searched through very many slides sent me by Captain F. F. Carroll from his case at Khartoum, without success, and only found, at last, one group of Leishman-Donovan bodies. The same point was noted by

[1] Dutton and Todd. Koch, *vide* leading article, *British Medical Journal*, February 24th, 1906.

[2] Nicolle, C. *La Semaine Médicale*, April 24th, 1908.

[3] Rogers, L., I.M.S. *Milroy Lectures*, 1907. *See also* Review Supplement to this Report.



L. Bousfield

Fig. 25.—Map showing Proved and Suspected Cases of Kala-azar in Kassala Province

Red Type indicates Towns and Villages in Kassala Province

P = Definitely diagnosed cases S = Suspected cases

Captain L. Bousfield in several of his cases, while Major Marshall, I.M.S., had great difficulty in finding the parasite in the case of the late Dr. MacTier Pirrie. In no case has the parasite been descried in the peripheral blood, though observers in India[1] have recorded finding it in 70 per cent. of their cases. The severity of the case appears to have little or no connection with the number of "bodies" found.

Owing to the diminution of the number of leucocytes, the chances of finding the "bodies" in the peripheral blood are much diminished. To obviate this difficulty, I have twice had recourse to the following device:—

A suggestion for facilitating diagnosis

The skin is well rubbed over a given area with ointment of tartarate of antimony, this being repeated daily until pustulation takes place. Films are made from the pustules, in which many leucocytes are to be seen; and there would appear to be a much greater probability of diagnosing a case by this means than by ordinary examination of the peripheral blood. In both my attempts I failed to find any parasites; but I was dealing with a case where they were only found with great difficulty, even in the splenic blood.

I think this method should be tried before having recourse to spleen puncture, but where it fails, I can thoroughly endorse Captain Bousfield's experience, that, if made with a small needle, the latter process is quite safe.

Differential diagnosis

DIFFERENTIAL DIAGNOSIS. Leaving out of consideration such rare causes of splenomegaly as Leukæmia, Tuberculosis, etc., three conditions are likely to give rise to confusion in the diagnosis of kala-azar in the Sudan and Egypt. These are Malta Fever, Malaria, and Egyptian Cirrhosis of Liver and Spleen. This difficulty is greatly enhanced by the extremely small number of "bodies" to be found in many Sudan cases of kala-azar; so that a positive diagnosis is often impossible, except post mortem. The diagnosis, by exclusion of other conditions, is also very difficult in the out-stations of the Sudan, where Widal's reaction for Malta fever is, at present, out of the question. I can only call attention to the "Milroy Lectures" by Major L. Rogers, I.M.S. (1907), where the question is most thoroughly treated.

A continued fever, accompanied by enlargement of liver and spleen, resistant to ordinary doses of quinine, and tending, through periods of wasting and debility, with œdema of extremities, to a fatal termination, usually determined by some septic complication, is almost certain to be kala-azar. A point of great importance, and which can be demonstrated with no more complicated apparatus than a thermometer, is the double daily rise of temperature, when a four-hourly chart is kept.

Where blood-counting is possible, a marked leucopænia is almost diagnostic of kala-azar.

Egyptian cirrhosis of liver and spleen

I cannot leave the subject of differential diagnosis without a reference to "Egyptian Cirrhosis of Liver and Spleen." This, like kala-azar, is a chronic disease, with splenomegaly and enlargement of the liver, ascites, œdema of the lower limbs, pigmentation of skin, resistance to quinine, and a tendency to a fatal termination. For a most interesting account of the disease, I would refer medical readers to the paper by Dr. L. Phillips, in the Records of the Egyptian Medical School, Vol. II., 1904, entitled, "The rôle played by Malaria in the production of Ascites." The reader will be at once struck by the close resemblance between the cases recorded and kala-azar. Although Dr. Phillips demonstrated the presence of malarial parasites in many of his cases, this is far from being proof that the disease is malarial, as malaria co-exists with everything in countries where it is prevalent.

It is curious, too, that in the Sudan, where malaria is more severe than in Egypt, these cases do not occur; or, at least, have not been noted, except occasionally in Egyptians.

[1] Patton, W. S. (1907). *Scientific Reports of Government of India.*

Of all the blood-counts given, not one is like that of malaria. On the other hand, none of the blood-counts at all resemble kala-azar, and I am informed by Dr. Alec Fergusson, who has examined very many pathological spleens at Kasr-el-Ainey Hospital, that he has never yet seen the Leishman-Donovan body in spleens examined by him.

On the whole, there seems to be good reason to consider this cirrhosis of liver and spleen as *sui generis*, but it must be admitted that the patients usually present a picture most similar to kala-azar, and a close study of a number of cases, with enquiry as to origin, and an investigation into such points as house infection, is required before it can be assumed that the two conditions are not identical.

My own opinion, formed on admittedly incomplete evidence, is that Egyptian Cirrhosis is a disease apart; and that kala-azar, if present at all, is exceedingly rare in Egypt.

Cases

CASE A

No. 2406. Nafr. Fadl Nadi Hafez, Department of Works

PREVIOUS HISTORY. Enlisted May 15th, 1905. Was sent to Khartoum and thence to Senga, arriving at the latter station about April, 1906. His first admission to hospital was for "intermittent fever" on September 20th, 1906. From that date until December, 1906, his medical history sheet shows four separate admissions for intermittent fever. He was then sent to Khartoum, where he was at once admitted to hospital for "malarial fever," remaining thirteen days under treatment. He was then discharged, but was again admitted on February 25th, 1907, and then sent, by sick convoy, to Cairo, for change of air. On arrival he was granted a month's sick furlough, after which he returned to hospital very ill. He died on May 16th, 1907.

He first came under my personal notice on admission to hospital after his sick furlough.

GENERAL CONDITION. On April 7th, 1907, I found this man to be in a very serious condition. The temperature rose to 104° F. on that evening; the lower extremities were œdematous, the patient greatly wasted. The spleen was enlarged to the umbilicus; and the liver to about two finger-breadths below the costal margin. The temperature continued "spiky," but no four-hourly chart was kept. No malarial parasites were found. During the first week in May he began to suffer from septic diarrhœa, which was very hard to control, and which led to his death on the 16th of May. Spleen smears made after death showed numerous Leishman-Donovan bodies.

CASE B

No. 1993. Nafr. Said Abdul Wahid, Department of Works

PREVIOUS HISTORY. The patient was in good health when he was sent to Senga in the summer of 1906. For some eight or nine months he was in good health at that station, but during the last three months has suffered constantly from fever, which has brought about his transfer to Khartoum Hospital.

PRESENT CONDITION, JULY 2nd, 1907. Patient is very weak and anæmic. He has a constant rise of temperature, but no nightly sweats or cough.

Diarrhœa has been constant during the past three weeks, and appears to be uninfluenced by drugs.

The motions are liquid, normal in colour, and never contain blood. The liver is enlarged and tender. The spleen projects downwards and inwards to the level of the umbilicus. It can quite easily be seen through the wasted abdominal walls; and is very hard, but not tender to the touch.

Patient has been taking quinine for a long time without much benefit, and he is obviously going down hill.

(The larger doses of quinine, recommended by L. Rogers, were subsequently tried, but the patient was too far advanced to derive any improvement from them.)

On splenic puncture, Leishman-Donovan bodies were found in very small numbers, after prolonged search.

The patient died on July 2nd, 1908, the death being caused by diarrhœa and exhaustion.

The above notes were kindly furnished by Capt. F. F. Carroll, R.A.M.C.

CASE C

No. 1128. Nafr. Mohammed Ibrahim Osman, Medical Corps

PREVIOUS HISTORY. This soldier left the M.C. Depôt in Cairo on August 23rd, 1905, being at that time in excellent health, and proceeded to Kassala. On arrival at Kassala he spent seven days in hospital as the result of a chill contracted on the journey. When discharged he was at once sent to Mafaza, where, for about ten months, he enjoyed good health.

At the end of that time (*i.e.* in July, 1906), he was suddenly taken ill with fever, which continued to be severe during the next few months, the temperature rising every day in spite of quinine. In November he was transferred to Gedaref, still very ill, and remained in hospital there for twenty-five days, before transfer to Kassala.

After seven days in Kassala Hospital he was discharged to duty; but after attempting to work for about a week, he was re-admitted, and remained under treatment for about two months. He was at first thought to be suffering from enteric fever, but was finally invalided to Cairo, diagnosed "Malaria." While at Mafaza he lived in a grass hut in the Zaptea, adjoining the huts of the Arab police, in the same compound, but he was in sole possession of his own hut. He admits that he patronised the Arab prostitutes, but he declares they were all in good health.

CONDITION ON ADMISSION. The patient is wasted and weak. The spleen is enlarged to half a hand's breadth below the costal margin. The liver is, apparently, about normal. No œdema of legs. Bowels normal. The appetite is enormous, to an extent that strikes me as pathological. The skin of the face is darkly pigmented. The temperature shows a *double* rise in the twenty-four hours.

Blood is free from malarial parasites:—

Red corpuscles	5,000,000
White „	872

On splenic puncture the Leishman-Donovan parasite is found in small numbers; chiefly free in the blood, but a few in leucocytes.

The stools were frequently and carefully examined. On one occasion they were found to contain very numerous organisms of a peculiar kind, small disc-shaped bodies, slightly larger than a red corpuscle, and apparently ciliated, being very actively motile through the agency, apparently, of some lashing organ, as surrounding particles were thrown into motion by it. These were only found on one occasion; subsequent careful search proving negative. I have since found somewhat similar bodies co-existing with *Amœba coli*, in a case of acute dysentery.

PROGRESS. The temperature continued to show an irregular double daily rise, until at the end of June, the patient was put on very large doses of quinine, fifty grains a day. The result was a great improvement, the temperature falling to, and remaining at, normal a few days later. This improvement lasted about three weeks, the patient gaining in weight and looking much better. Splenic puncture, at the end of that period, was normal; and the leucocyte count had risen to about 3000, the red corpuscles being about 4,800,000. Some weeks later, the temperature had recommenced (August 5th). On enquiry it was found that, owing to the patient's complaints, the medical officer in charge had stopped the quinine about a week before. Sharp attacks of diarrhœa from time to time. Patient looking very ill. No parasites to be found in peripheral blood. Careful search in films of leucocytes, made from artificially produced pustules, proved to be negative. Splenic puncture again shows Leishman-Donovan bodies, though in very small numbers. Quinine resumed.

CONCLUSION. The patient had been recently exempted from military service on legal grounds, and no longer belonged to the army. He now insisted, against all advice, on leaving the hospital (20th of August).

His death occurred at his village a week later. No post mortem possible. Duration of illness thirteen months. The remarkable improvement of this patient under vigorous quinine treatment (fifty grains daily) was most striking. I was at one time almost prepared to see him recover; but he found the large doses of quinine difficult to tolerate, and succeeded in getting the drug stopped. Whether the recurrence would have come in any case, it is impossible to say.

CASES D AND E

Arab Police Nafr. Abdallah Ahmed }
„ „ „ Abd el Wahab } Sennar Province Staff

PREVIOUS HISTORY. These two men had spent most of their police-service together in Sennar District. They were in good health when they proceeded to Mafaza in May, 1907.

Both were recalled to Senga early in July, and both reported sick with fever towards the end of that month, being admitted to Senga Hospital. They were diagnosed "malaria" by the medical officer in charge, but thought to be unusually bad cases. In transferring them to Wad Medani for change of air and further treatment, he calls attention to their peculiar temperatures, and to his failure to influence them by quinine.

ON ARRIVAL AT WAD MEDANI. Both patients were extremely ill, the temperature being of the high intermittent type, while there was great emaciation, slight diarrhœa, cough, and sometimes delirium. The spleen was considerably enlarged in both cases, and the liver to a less degree. No malarial parasites could be found.

On September 12th, Nafr. Abdallah Ahmed developed a sore mouth and œdema of the face and neck, which declared itself as "gangrene of the cheek" on September 14th. He died on the morning of September 16th. The post mortem examination showed that the heart, lungs, kidneys and gastro-intestinal tract were normal; the liver enlarged, but of normal colour and consistence; the spleen greatly enlarged, purplish in colour, and soft and grumous.

Nafr. Abd el Wahab, after a few days, also suffered from gangrene of the face, commencing at the upper lip. He died on the morning of September 18th, 1907. The post mortem report closely resembles that of Abdallah Ahmed.

The close similarity in the history of these two men is most striking, in view of the fact that they were probably infected by the same strain of parasite and at the same time.

These notes are furnished by Mulaziem Awal A. E. Kamar, Medical Corps, who diagnosed them kala-azar, the diagnosis being confirmed by Dr. A. Balfour, Gordon College, Khartoum, from spleen smears sent for examination.

CASES F AND G

Two cases of kala-azar have hitherto come to light in British officials in the Sudan. The late Dr. MacTier Pirrie, who returned to England suffering from a chronic fever contracted south of the Blue Nile, was diagnosed as kala-azar by Dr. Gulland, of Edinburgh and Major Marshall, I.M.S., the diagnosis being confirmed post mortem by the discovery of the Leishman-Donovan bodies in spleen smears.

The case is to be published elsewhere by the gentlemen who observed it, and through whose kindness I have been enabled to mention it.[1]

A British officer of the Egyptian Army, who returned to England ill, after having been stationed at Gallabat, has now been found to be suffering from kala-azar.[2]

This discovery was made by Sir Patrick Manson, K.C.M.G., who has kindly made me aware of the confirmation of the diagnosis by the finding of the parasites in blood withdrawn from the liver.

A remarkable fact is that in both the above cases a positive reaction to Widal for enteric was given at one period of the disease.

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[1] *Lancet*, August 15th, 1908.

[2] Unhappily this case has also terminated fatally.

Observations on Kala-azar in Kassala Province

BY

L. Bousfield, M.A., M.D. (Cantab.), M.R.C.S., L.R.C.P. (Lond.), R.A.M.C.

Bimbashi, Egyptian Medical Corps, S.M.O., Kassala

Since August, 1907, eight cases of this disease have been definitely diagnosed in the province, and all have terminated fatally, while thirteen other cases, extremely suspicious, have come under my observation or to my knowledge, of whom nine are already dead.

Number of cases

It is almost impossible to give any trustworthy idea of the prevalence of the disease, as the towns and villages are far distant one from another, usually being visited but once a year by a doctor, and then only for a day or two.

Thus cases positively diagnosed have only been found at Kassala (7) and Mafaza (1), and prolonged observations on cases have only been carried out at Kassala and Gedaref, namely, where doctors were present.

However, the positive diagnosis of eight cases presents a serious picture when one remembers the fact that for every native admitted there are five or more who do not seek medical assistance.

It is a matter of extreme difficulty to trace the history and movements of the patients. Indeed, in some cases it is almost hopeless, for many have no fixed abode, are often admitted very ill, have no friends to speak for them, and, further, talk in various dialects. Thus of all the cases it has only been possible to find out definite abodes and house contacts in six out of a total of twenty-one, and even in these six cases sometimes the residence in a tukl (hut) or hosh (compound) was only for a few weeks.

Of the co-inhabitants I have had an opportunity of examining, I have found none suffering from the disease or presenting signs of ill-health suggestive of kala-azar, and in the few instances where I have been able to search the dwellings I have been unable to find bed-bugs.

Bed-bugs in Kassala Province

However, I believe bed-bugs exist in every town and village of Kassala, and, personally, know of their existence in Kassala, Gedaref, Gallabat, Mafaza, Tomat, Sofi, and Turkelein. Specimens from the first three towns were sent to Dr. Balfour for examination, and Mr. H. King has identified them as *Cimex lectularius*.

Dogs are very common everywhere, but, unfortunately, this possible source of infection was not studied, since the observations on the liability of dogs[1] transmitting the disease were not then known to me.

To study the disease properly in this province, one specially appointed is required, who has all his time at his command for making lengthy observations and carrying out the difficult but important work of tracing these cases to their source in the various places.

Historical

The disease is apparently new or but recently recognised, for following Dr. Neave's case in 1904, the next one observed was by Captain Cummins in May, 1907, and in this province, though a case was suspected early in June, 1907, it was not until the third splenic puncture (August 30th) that Leishman-Donovan parasites were found, and since that date seven other cases have been definitely diagnosed.

The very great importance of recognising the appearance of this disease in a new country is such that I append two tables, "A" of those cases definitely diagnosed by the discovery of the parasites, and "B" of those extremely supicious of kala-azar, but where the parasites were not found.

[1] Nicolle, C., *La Semaine Médicale*, March 11th, 1908, and MM. Ch. Nicolle et Ch. Comte, *La Semaine Médicale*, April 22nd, 1908.

TABLE A. KALA-AZAR. (Parasite Found)

	Case I	Case II	Case III	Case IV
Age and Sex ...	♂ 23	♂ 25	♂ 25	♂ 26
Nationality... ...	Abyssinian	Egyptian	Abyssinian	Arab, Maria Tribe
Duration of Illness	2 years, Autumn, '05. Died Nov. 6th, '07	$3\frac{1}{2}$ months, Oct., '07. Died Feb. 4th, '08	$2\frac{1}{4}$ years, Autumn, '05 Died Dec. 22nd, '07	8 months, Aug., '07. Died Mar. 24th, '08
Villages and Towns where Ill (Name underlined where first ill)	Addayagi (Erithrea), Kassala, Golsa, Kassala, Debelweit, Kassala	Kassala	Azzein (Erithrea), Karkabel, Glodet, Kassala	Mafaza
Type of Fever ...	Temperature usually sub-normal. Occasional rises to 101° to 105° for 1 to 2 days	High fever 4 weeks, then 98° to 99° for 5 weeks — then higher fever, seldom coming to normal	Intermittent fever, followed by normal	High intermittent fever
Type of Parasites (Splenic Puncture)	Considerable numbers, mainly free. Long oval forms mainly	Few well-developed parasites	Well developed, none found in cells	Extremely few found. Pigment collection
Peripheral Blood...	No malaria. No Leucocytosis. No parasites in white cells	No malaria. Leucopænia. No parasites in white cells	No malaria, Leucopænia, almost all mononuclears	No malaria. Leucopænia
Liver	Not enlarged, apparently reduced in size	Enlarged. Two fingers' breadth below costal margin	Not enlarged	Enlarged $1\frac{1}{4}$ inch below costal margin
Spleen	1 inch below umbilicus	1 inch below costal margin	1 inch below umbilicus. Tender	2 inches below costal margin
Urine...	Albumen Bile absent	Albumen absent Bile absent	Albumen trace Bile	Albumen Bile
Complications ..	Diarrhœa. No pain	Pseudo-diphtheritic tonsillitis. Duodenal ulcers, with epigastric pain	Very collapsed. Died 5 days after admission. No pain	Pains in shin bones. Epistaxis
Jaundice	Absent. Conjunctivæ, yellow	Absent. Conjunctivæ, yellow	—	—
Œdema	Feet (terminal)	Absent	Feet (terminal)	Legs (terminal)
Treatment	Quinine no effect. Heavy and increasing doses of $HgCl_2$ useless	Quinine apparently beneficial at first. Later Atoxyl and $HgCl_2$ injections together with Fuchsine pills	Admitted Aug. 14th, 1907, with fever. 30 grs. and injections of quinine given. Temperature normal after 8 days and patient discharged well. Re-admitted Dec. 18th, 1907	Quinine had no effect. Atoxyl and sublimate injections together with Fuchsine pills
Periods of Improvement	Yes	Yes	Yes, very marked	Yes
Pigmentation ..	None	None	None	None
House Infection History	Single. All living in hosh well. No bugs found	Single. Other soldiers healthy, but much malaria. No bugs	Single. No definite abode	Single. Case V. lived in police lines. Bugs denied

TABLE A. KALA-AZAR (Parasite Found)—*continued*

	Case V	Case VI	Case VII	Case VIII
Age and Sex ...	♂ 22	♂ 9	♂ 30	♂ 28
Nationality	Abyssinian	Arab	Sudanese	Sudanese
Duration of Illness	6 months, Oct., '07. Died April 8th, '08	$4\frac{1}{2}$ months, Dec., '07. Died April 29th, '08	4 months (?) Autumn, '07. Died Jan. 25th, '08	$7\frac{1}{2}$ months, Oct., '07. Died May 14th, '08
Villages and Towns where Ill (Name underlined where first ill)	Mafaza	Kassala	Gharb el Gash (a Kassala suburb)	Khatmia (a Kassala suburb), Debeleweit
Type of Fever ...	Seen but once. History of continuous fever	Perpetual high remittent, 104° to 101°	Intermittent, subnormal, last 2 weeks	Intermittent, frequent intervals of 2 to 3 days. Normal temperature
Type of Parasites (Splenic Puncture)	Large number of big parasites	Many small parasites; very many blood platelets	Only one typical parasite found	Considerable numbers of round and oval forms. Pigment collections
Peripheral Blood...	No examination	No malaria. Leucopænia	No malaria	No malaria
Liver	Slightly enlarged	Enlarged 3 inches below costal margin	Slightly enlarged	Enlarged. Hand's breadth below costal margin
Spleen	2 inches below umbilicus	1 inch below costal margin	Considerably enlarged	1 inch below umbilicus
Urine...	—	Albumen absent Bile absent at first, later present	No albumen No bile	Albumen Bile
Complications ...	No pain. No complications when seen. Constipation	No pain	No pain	No pain. Persistent terminal epistaxis
Jaundice	Absent. Conjunctivæ, yellow	Absent	Absent	Conjunctivæ, yellow
Œdema	Absent when seen	General œdema marked	Not noted	Legs (terminal)
Treatment	No improvement on quinine, 15 grs. daily	Quinine, 40 grs. daily, no effect	Quinine, no effect	Quinine 40 to 60 grs. daily, slight improvement. Thymol 6 grs. daily, no effect
Periods of Improvement	Unknown	No	Unknown	Yes
Pigmentation ...	None	None	None	None
House Infection History	Single. Brother and brother's wife with whom living, well	Mother and two young sisters healthy. No bugs found	No definite abode	No definite abode

TABLE B—SUSPICIOUS KALA-AZAR CASES

	Case I	Case II	Case III	Case IV	Case V	Case VI
Age and Sex	♂ 35	♀ 11	♂ 6	♂ 26	♂ 22	♀
Nationality	Sudanese	Abyssinian	Abyssinian	Egyptian		
Villages and Towns where ill	*Gharb-el-Gash* (a Kassala suburb)	*Gallabat*	(?) *Gallabat*	*Mafaza*, Geili	*Mafaza*	*Mafaza*
Duration of Illness	No history. Admitted moribund. Removed by friends. Died outside	2 years. Seen only once	$1\frac{1}{2}$ years. Seen but once	Six months, August, 1907. Died Feb. 1908	Five months, Aug., 1907. Died Dec. 12th, 1907	Several mos. Died Dec. 27th, 1907
Type of Fever	(?) Subnormal 36 hours	99° when seen	No fever when seen	Periods of fever 100° to 102°, alternating with periods of normal	Continuous, remittent, 100°–103°	Fever present, type unrecorded
Blood Examination	Not examined	Spleen puncture. No malaria, no kala-azar. Many blood platelets	Peripheral blood. No malaria. Leucopænia	Peripheral blood. No malaria. Leucopænia	—	—
House Infection History	Unknown	Mother well, baby brother enormous spleen, but well nourished	Unknown	Case IV, an Egyptian official; Case V, his male servant; Case VI, his female servant—all from one compound. All died within three months of one another		
Liver	Considerably enlarged	Enlarged	Much enlarged	Not enlarged	Enlarged	Not enlarged
Spleen	Considerably enlarged	Considerably enlarged	Much enlarged	Enlarged	Considerably enlarged	Not enlarged
Condition and Complications	Very weak and wasted. Conjunctivæ, yellow	Marked wasting and weakness. Conjunctivæ, yellow	Very weak and emaciated	Emaciation and weakness marked. Slight jaundice, œdema of legs (terminal)	Progressive weakness & wasting. Dysentery, last 7 days	General œdema at the end. Comatose, last 2 days
Treatment	—	—	—	Temporary improvement under quinine, but steady emaciation	Quinine, no effect	Quinine, no effect

	Case VII	Case VIII	Case IX	Case X	Case XI	Case XII	Case XIII
Age and Sex	♂ 25	♂ 23	♂	♂	♂ 22	♂	♂ 22
Nationality	Egyptian	Arab	Arab		Arab	Arab	Abyssinian
Villages and Towns where ill	*Umbrega* (Abyssinian frontier)	*Gallabat*	*Mafaza*	*Gallabat*	*Gallabat*	*Mafaza*	*Kassala*
Duration of Illness	Several months (?) living	Several mos. Died 21st May, 1908	Several mos. Died 8th Oct., 1907	Several mos. Died 16th Dec., 1907	Several mos. Died 19th Dec., 1907	4 months. Still living	$2\frac{1}{2}$ years. Died 10th April, 1908
Type of Fever	Periodic waves	Continuous fever, 100° to 102°	Continuous fever, 100° to 103°	Continuous fever, 99° to 101°	Continuous fever, 100° to 103°, 104°	Continuous, 99°-normal or subnormal	Periodic attacks, continuous last 2 weeks
Blood Examination	Spleen punctures, no malaria, no kala-azar	Spleen punctures, no malaria, no kala-azar	—	—	—	Spleen puncture, no malaria, no kala-azar	Spleen puncture, no malaria, no kala-azar
House Infection History	—	—	—	—	—	—	No definite abode
Liver	Enlarged	Not enlarged	Not enlarged	Enlarged	Enlarged	Much enlarged	Not enlarged
Spleen	Much enlarged	Enlarged	Much enlarged	Greatly enlarged	Enlarged	Much enlarged	—
Condition and Complications	Progressive wasting and weakness, conjunctivæ, yellow	Extreme emaciation and weakness, conjunctivæ, markedly yellow	Continuous hæmorrhage from gums and nose	Emaciation and weakness marked	Pigmented patches in many places, last 2 days diarrhœa and vomiting	Very emaciated	Very wasted and weak. Pain in bones of leg. Œdema of legs last 7 days
Treatment	Fever lessened by heavy doses of quinine—but progressive emaciation	Quinine, no effect	Quinine, no effect	Quinine, no effect	Quinine, no effect	Quinine, no effect	Quinine, grs. 40-60, no effect
Post Mortem Examinations	—	—	—	Spleen and liver enlarged, no other condition found	Spleen and liver enlarged, no other condition noted	—	—

Most of the cases in Table "B" refused to react to heavy and continued doses of quinine, and other conditions, such as tubercle, malaria, abscess of liver, and splenomedullary leucocythemia, were usually excluded; malignant disease is practically out of court owing to its extreme rarity in this Province. In all cases, when spleen puncture was performed, examination of peripheral blood was also made.

Unfortunately it must be said "usually excluded" for it must be noted that some cases were seen but once, and others were seen by a medical officer who had no microscope and was unfamiliar with kala-azar.

These tables give summaries of the cases, and they have been included, as it was thought that they might be useful in following up in the future this disease in the province.

Five are included in Table "B," whose splenic blood was examined with negative results, but this is done because, in my small experience, it is extremely hard in many cases to find the parasites.

In the first case it was not till the third splenic puncture that parasites were seen, and in several others the results from the first and second punctures were negative. Often only one film out of four or five would present parasites, and even then in very small numbers. The average time spent for microscopic diagnosis has certainly worked out at nearly four hours each case; in only three cases were parasites found in the first films examined.

Types of parasites

TYPES OF PARASITES OBSERVED. In all cases, except two, only free forms were found. It was noteworthy that in all cases the free forms seemed to be about the same stage of development, smaller and younger forms were seldom observed.

In cases I., III., IV. and VI., practically all the parasites were of an elongated, almost torpedo shape, while in cases II., V. and VIII., nearly all were large and oval.

Case VI. presented many small parasites, and the splenic blood was remarkable from the enormous number of blood platelets it contained; this was the only juvenile case of the series.

In case VII. only one absolutely typical Leishman-Donovan body was found in six slides examined.

In none of the spleen smears from those of Table "A" were malarial parasites found, and in only two were collections of pigment noted; this is probably accounted for by the fact that the patients were drenched with quinine prior to the examination. Peripheral blood examinations never exhibited parasites, either free or in leucocytes.

In none were malarial parasites found, and in none were any marked changes observed, except those of anæmia.

In four of the positive cases there was marked leucopænia, and in one case nearly all the white cells were mononuclear leucocytes. In four cases the blood was very "watery," and spread on the slides extremely badly.

Splenic puncture

Spleen puncture was carried out by a small, long hypodermic needle and "all-glass" syringe, under strict aseptic precautions, and though some sixty odd splenic punctures have been performed, in many cases on very anæmic subjects, yet in no case has any bad result followed.

One case had pain over the site of puncture for twenty-four hours, and another, whose temperature was 100° previously, had a rise to 105° on the evening following the puncture, but the temperature fell again to 100° on the following day.

The Source of Infection is unknown, and apparently these cases are sporadic.

House infection

The only instance of house infection occurred at Mafaza, and in these cases no positive diagnosis was made, though personally I have no doubt they were kala-azar, and had their tukls and compound burnt down.

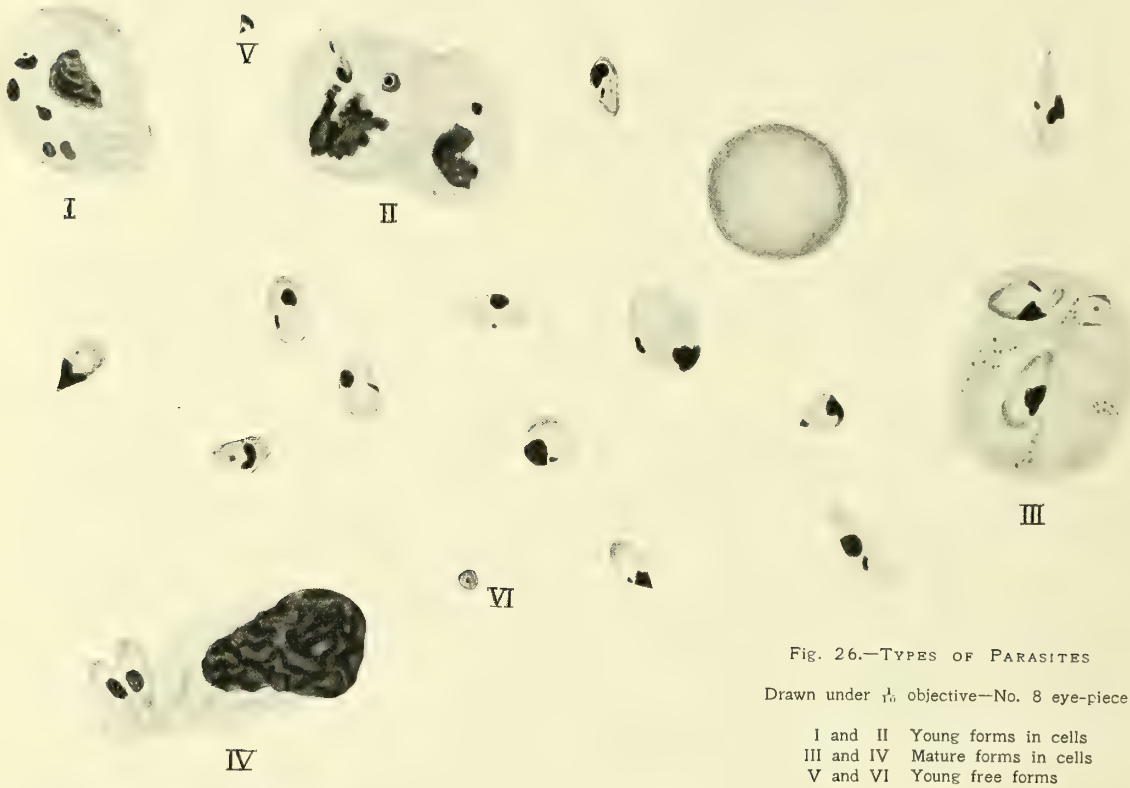


Fig. 26.—Types of Parasites

Drawn under $\frac{1}{12}$ objective—No. 8 eye-piece

I and II Young forms in cells
III and IV Mature forms in cells
V and VI Young free forms

From original coloured drawing by L. Bousfield

I only saw the Egyptian official on two occasions at Gedaref, and his peripheral blood showed no malaria, but marked leucopænia; splenic puncture was absolutely refused.

These cases are IV., V. and VI. in Table "B," and it is to be noted that the master and male servant became ill in August, 1907 (however a malarial period), the female servant a little later. The male servant died on December 25th, 1907, the female servant on December 27th, 1907, and the master in February, 1908; the summaries of their histories are given in the Table.

Is Abyssinia to blame?

The possibility of the introduction of the disease by Abyssinians has been enquired into, and it certainly is striking that out of the eight positive cases, three were Abyssinians (37·5 per cent.), and of the thirteen suspicious cases three were of this nationality. Considering their comparatively small number it is a suggestive fact.

I inspected all the Abyssinian men who could be collected at Gedaref, but found all healthy, except one suffering from malaria.

These facts were ascertained about the following towns :—

Analysis of cases

1. *KASSALA*. Many Abyssinians live here, and the number of local cases are four proved, two suspicious—all fatal.

2. *GALLABAT* is constantly full of Abyssinians. Five suspicious cases, three already fatal. I also saw many children with enormous spleens, but malaria is rampant here during and after the rains.

3. *GEDAREF*. Comparatively few Abyssinians; the Mamour being able to collect only thirteen men for my examination. No known cases.

4. *MAFAZA.* But few Abyssinians live here, though a fair number pass through, staying for a short time on their journey. Number of proven cases two (one an Abyssinian), and suspicious five.

Captain R. B. Black found two Arab policemen with the disease at Senga, but they had contracted it at Mafaza; Dr. Andrew Balfour found the Leishman parasites in smears from these cases.

Captain S. L. Cummins also proved kala-azar in a Tumergi, who developed the disease at this station, and died in Cairo.[1]

Thus the total number of proved cases from here is five.

5. *SOFI and TOMAT.* Two suspicious cases were seen at the former and one at the latter.

A few Abyssinians visit these places, but seldom live for any length of time.

These three cases were weak, emaciated, with large spleens and livers, and though in one case spleen smears were taken, and in the others peripheral blood films, yet in none were malaria or kala-azar found. They were placed on quinine, and it was hoped that they would be seen on my return journey, but as this was not the case, they were not included in Table "B."

A rough map is given on page 103 showing the surroundings of Kassala Province, with the number of suspicious and proved cases under each town.

Consideration of death rates

DEATH RATES. Though the registration of births is most inaccurate, that of deaths is fairly reliable.

The number of deaths at the following places are given:—

Year	Kassala	Gedaref	Gallabat	Mafaza
1906	183	311	26	53
1907	299	254	137	104
1908 ... ... (to end of April)	48	51	32	36
—	144	153	96	108

The last row shows the number of deaths in 1908, if the same rate were maintained during the remaining months of the year; but this is quite unreliable, since the deaths appear usually greater during the last four months than during the first and middle four.

Further, these populations vary very greatly, and so statistics are very unreliable. However, the death rate at Mafaza seems to be steadily increasing.

Duration of illness

DURATION OF ILLNESS. The average duration of the positive cases was apparently 10·5 months, the longest being $2\frac{1}{4}$ years, and the shortest $3\frac{1}{2}$ months.

The *incidence* of the disease seems to be from August to December, *i.e.* during and subsequent to the rainy and cool weather. Three definitely dated the beginning of their illnesses to August, one to September, and three to October.

This probably corresponds with a temperature below 75° F., anyhow during the night hours, and so falls in with Rogers' statement[2] that the parasites develop best at a temperature below 75° F.

[1] Cummins, S. L., February, 1908, "Kala-azar in the Anglo-Egyptian Sudan." *Journal of the Royal Army Medical Corps.*

[2] Rogers, Leonard, I.M.S., 1907 Milroy Lecture. Lecture II.

CLINICAL FEATURES. In all, marked weakness and general emaciation were very evident.

Pain was absent, except in three cases where it was insignificant (one splenic pain, and two pains in tibiæ).

Signs and symptoms

All the positive cases showed splenic enlargements, six to a marked degree, while five showed the liver increased in size, three markedly. In four cases the conjunctivæ were noticeably yellow without bile being present in the urine, while three were jaundiced. In four cases albumen, from a trace to large quantities, was present, and in all cases the urine was of low specific gravity, the average being 1012.

Pigmentation of the skin was not seen in any case, but was present in Case XI., Table "B." In all cases the tongue remained comparatively clear, and the appetite and digestion good, except just before death.

The complications noted were:—Pseudo-diphtheritic tonsillitis and epigastric pain due to duodenal ulcers (1).

Terminal persistent epistaxis (2).

Terminal diarrhœa (2).

Œdema of feet and legs (4).

General œdema (1).

Significance of œdema

In all cases where œdema appeared, death occurred within a few days, although the patient's general condition seemed no worse than before, and in my short experience the appearance of œdema is a premonitory sign of approaching death.

In no cases was ascites encountered, and in the case of general œdema there was no albumen, and the quantity of urine passed in twenty-four hours was normal.

DIAGNOSIS. This appears to be of considerable difficulty, owing to the prevalence of malaria.

Diagnosis

The main points noted in these cases were progressive emaciation and weakness; enlargement of liver and spleen; absence of pain; albumen and bile in the urine; and refusal to react to quinine.

Differential diagnosis

My experience is that malaria met with in this province (malignant tertian I believe to be very rare) seldom leads to liver enlargement, and if due to this cause the patient rapidly improves on quinine; and I am of opinion that every case with liver enlarged, together with the spleen, should be looked upon with the gravest suspicion, provided that local conditions can be excluded.

A positive spleen puncture settles the diagnosis, but a negative result is useless, for the parasites are so few, and so may easily be missed or be absent. Major Rogers, I understand, now considers spleen puncture unnecessary for diagnosis, but the risks are so small that this, together with the impossibility of finding the parasite peripherally, seems to me to justify this procedure.

The presence of albumen in the urine is important, for in the severer cases of 2,000 odd malaria patients last autumn albumen was never found except where something else was present to account for it, such as bilharziosis.

The yellow coloration of the conjunctivæ is helpful, but natives, especially Sudanese, often have a naturally yellowish tinge to their conjunctivæ.

Malta fever a difficulty

The presence of Malta fever enhances the difficulty, especially as the essentials for serum diagnosis are wanting in Kassala.

A difficult example was Case III., Table A, who was admitted to hospital on August 14th, 1907, with fever 102°, a spleen enlarged one inch below the costal margin, and no noticeable enlargement of the liver.

He was given quinine by injections and by the mouth; the fever lasted only eight days, and he was discharged comparatively well after eighteen days with a diagnosis of malaria. The spleen had considerably decreased in size.

He was not seen again till he was brought to hospital very collapsed on December 18th, 1907. His spleen was enlarged to one inch below the umbilicus, but there was no obvious liver enlargement. He had high intermittent fever for three days, sub-normal two days, and death occurred on December 22nd, 1907. Typical parasites were found in the spleen blood on December 19th, 1907.

Probably he was suffering from kala-azar when first admitted in August, and was unwittingly discharged wrongly diagnosed, possibly to be a source of infection to his neighbours during the following three months.

TREATMENT EMPLOYED. Many were treated with prolonged large doses (30–50 grains daily) of quinine, or by hypodermic injections (10–18 grains). Temporary improvement occurred in several cases, but as others similarly improved, not on quinine, it is doubtful if it is due to this drug. Treatment

One was treated with thymol 6 grains daily, but with no beneficial result.

Two were treated with intramuscular injections of atoxyl and corrosive sublimate alternately, combined with fuchsin pills[1]; charts and notes of these cases are given. All the cases were advanced, and so probably this treatment did not have a fair chance.

NOTES ON CASE II

S. S. a Wakil Ombashi, Medical Corps

Notes on cases

PREVIOUS HISTORY. No serious previous illness.

Arrived Kassala Province May 16th, 1906.

In 1906 proceeded to Gedaref for three days and then returned to Kassala.

On April 23rd, 1907, proceeded with S. M. O. on his inspection tour, and spent three days at Gedaref, three days at Gallabat, and three days at Mafaza, where he slept on an angareeb with the resident Medical Corps Tumergi, who has since gone on leave in good health.

He was sure he was not bitten by bed-bugs at Mafaza.

Proceeded on leave on June 15th, 1907, to Nazlet Ali Pasha, Benisuef Mudiria, Upper Egypt.

Good health on leave and returned healthy to Kassala, August 14th, 1907.

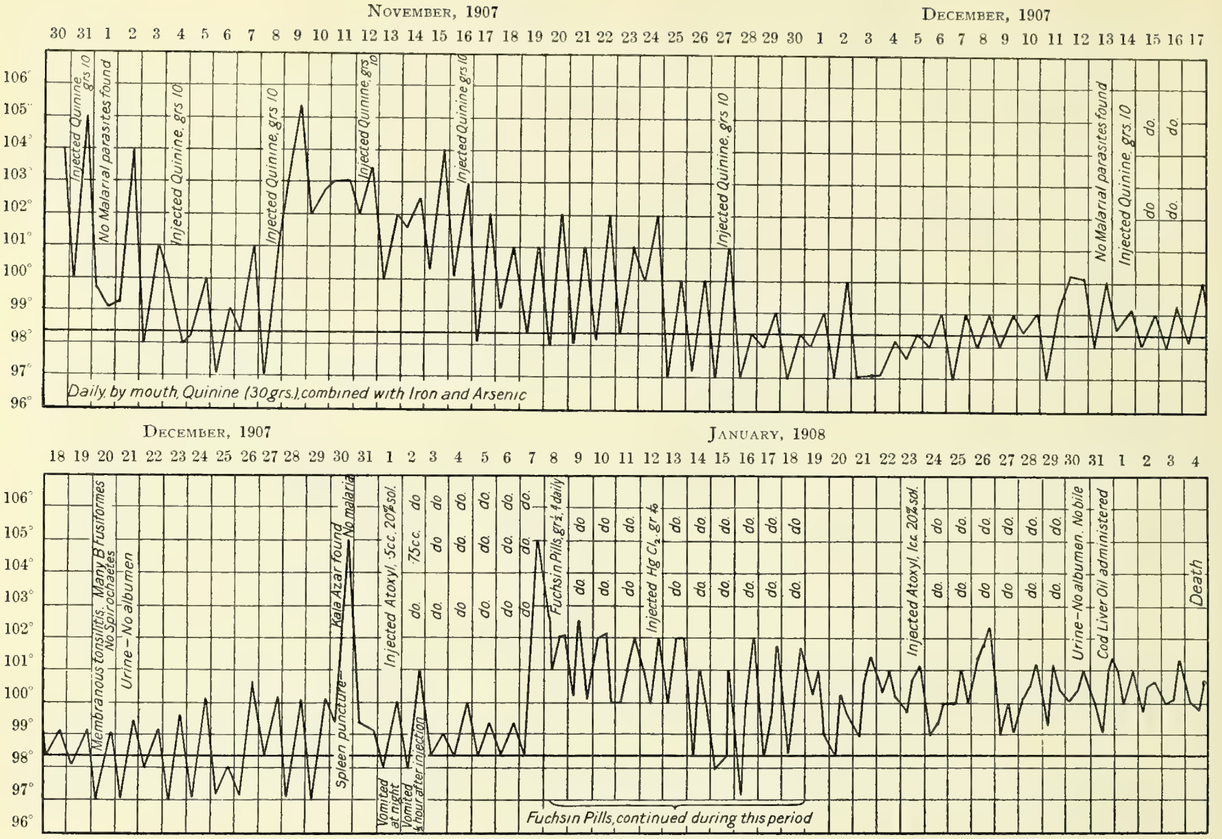
There was a very severe outbreak of malaria, and he was admitted to hospital October 12th, 1907, till October 21st, 1907, with malaria (?)—his spleen was enlarged to the costal margin. He was re-admitted on October 30th, 1907, and his temperature chart gives his pyrexia till the day of death.

No malaria was found in his blood, but it was quite the exception (7 per cent. positive) to find parasites, owing to all taking prophylactic doses of quinine regularly.

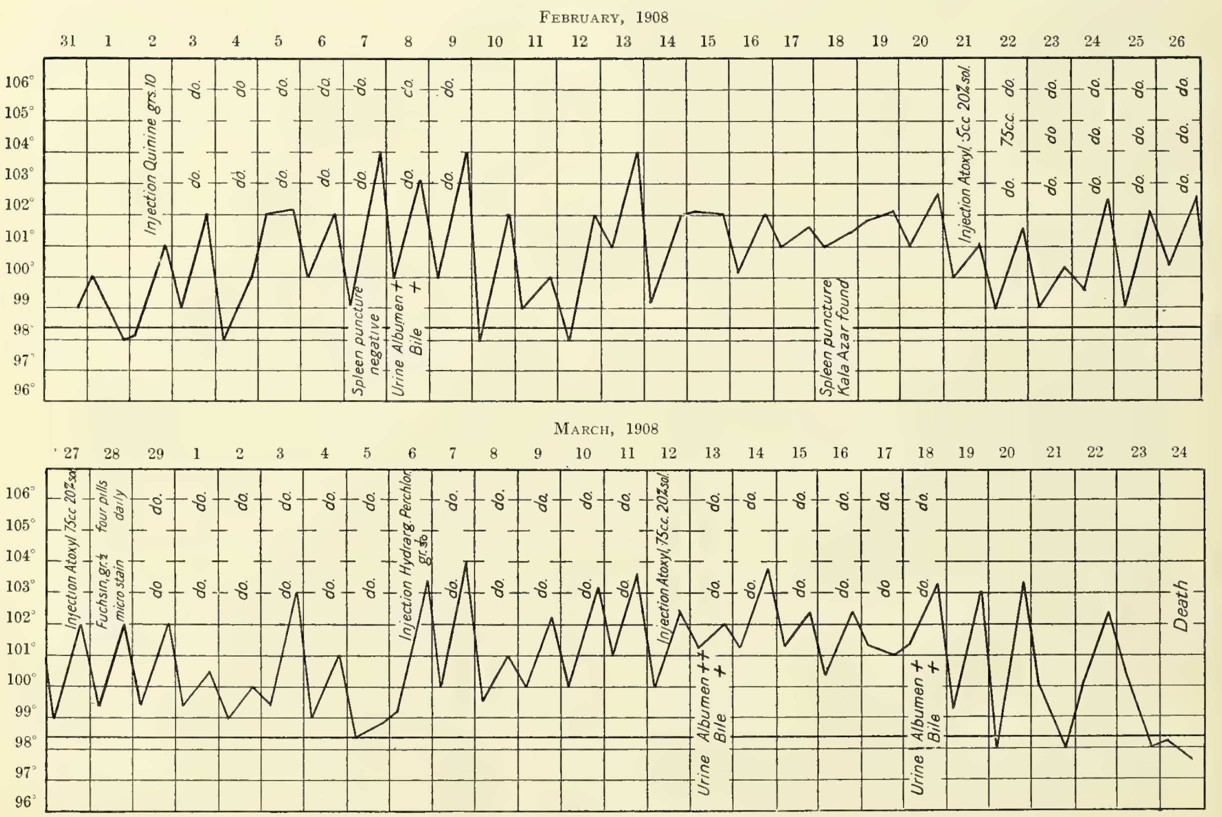
At first quinine by mouth and by injection seemed to have a beneficial result, but weakness and emaciation progressed steadily; his spleen continued to enlarge; his liver was distinctly increased in size, and kala-azar was suspected and spleen puncture proved positive on December 30th, 1907.

On December 19th, 1907, he had an attack of pseudo-diphtheritic tonsillitis, due to *Bacilli fusiformes*—no spirochætes were found, and there was no albumen in the urine. He was then placed on atoxyl-fuchsin-sublimate treatment (*see* Chart, *page* 116).

[1] Dosage, etc., as suggested by A. Nierenstein for Trypanosomiasis. *British Medical Journal*, July 27th, 1907.



Case II. Salaama Saadowi, Med. Corps. Kala-azar



Case IV. Idris Adam, a Policeman from Mafaza, aged about 26. Kala-azar

Fig. 27.—Temperature Charts

After the first atoxyl injection he vomited at night, which he had not done before.

Half an hour after the second injection he vomited again.

Otherwise he had no signs of any trouble from the arsenic; there was no gastritis, no diarrhœa, no pigmentation, no neuritis, and no ocular trouble.

The type of atoxyl used is unknown, but it was probably of English manufacture.

There was no medicinal fuchsin, so that used for microscopical purposes was employed, and this drug produced no ill effects.

On January 31st, 1908, the conjunctivæ were noticed to be distinctly yellow, but no bile could be found in the urine.

Four days before death he complained of epigastric pain, but there were no physical signs, and it was considered to be due to cod liver oil, which was then being administered.

His tongue was clean and his appetite good throughout, his sole complaint being of extreme weakness, except the terminal epigastric pain.

During the last three days his circulation began to fail, and his lungs presented hypostatic congestion.

The Source of Infection is a subject of great interest and importance in this case.

He lived in a barrack room with some 18 other soldiers, who appeared healthy except for malaria. It is practically certain that there were no bed-bugs, and angareebs (native bedsteads of wood and string) or iron bedsteads were not used. The only biting insects were ants or mosquitoes, mainly *Pyretophorus costalis.*

In May, 1906, he spent three days at Mafaza, but the man on whose angareeb he slept was quite healthy in March, 1906, when last seen.

He was quite well on leave, and I do not know if kala-azar exists at Nazlet Ali Pasha, but I find that a Tumergi (No. 1128) from Mafaza came to Kassala on December 3rd, 1906, and lived in the barrack-room with this man.

This Tumergi was admitted to hospital December 16th, 1906, and discharged December 19th, 1906, diagnosed as simple continuous fever. He was again admitted on March 23rd, 1907, as enteric fever and discharged April 21st, 1907.

Re-admitted on April 30th, 1907, as malaria, and remained in hospital till June 5th, 1907, when he was sent by sick convoy to Cairo, and there was definitely diagnosed as kala-azar by Captain Cummins.

Thus, during the periods he was living in the barrack-room he may have infected the patient S. S.

But the question "How?" still remains unsolved. No bed-bugs have been found, and all the soldiers declare they have never seen or been bitten by them, and, if such an occurrence had taken place, I am sure they would only too readily have complained. Further, the building is not very old, and has very little woodwork.

If infected from this source, S. S. had a quiescent incubation period of at least five and a-half months, the disease lying dormant during the hot weather.

SUMMARY OF POST MORTEM EXAMINATION. Autopsy was performed twelve hours after death. Only pathological conditions found are noted. Subcutaneous fat very scanty and distinctly yellow. Opposite the ninth right rib beneath the pleura an *encapsuled mass* $1\frac{1}{2}$ inches long and 1 inch broad was discovered. Post mortem findings

On cutting the capsule, soft, white, chalk-like material was found, like an old caseous gland; but if so, of very long-standing duration.

Right Pleural Cavity obliterated, except at apex, by a layer ($\frac{1}{4}$ to $\frac{1}{2}$ inch thick) of coagulated serum intersected by soft fibrous bands.

Lungs. No signs of tubercle, recent or old. Bases œdematous.

Aorta. Yellowish tinge, small raised patches (1 to 4 mm. long) beneath the internal coat.

Liver. Weight 5 lb. Much enlarged, slightly nutmeg. Marked fatty degeneration, especially noted in right lobe. No amyloid degeneration.

Spleen. Enlarged, weight 2 lb. 3 oz.; dark maroon; soft, but not diffluent. No sign of position of spleen puncture.

Stomach. Normal, but a large gland (?) 3 inches long, 1 inch broad, and $\frac{1}{4}$ inch thick beneath submucosa on lower border of anterior wall.

Parietal and Visceral Peritoneum showed many small sub-peritoneal hæmorrhages.

Duodenum. Two inches from the pylorus there were two small ulcers ($\frac{1}{4}$ inch by $\frac{1}{8}$ inch and $\frac{1}{4}$ inch by $\frac{1}{10}$ inch) with shelving edges, red bases, and apparently of not very acute formation.

The subjacent peritoneum was not thickened, and presented no tubercles. Probably the epigastric pain complained of four days before death was due to these ulcers.

Small Intestine. Marked congestion near the ileocæcal valve, with a few submucosal hæmorrhages.

Large Intestine. Intense congestion of cæcum and first eighteen inches of colon. Appendix normal.

Lymphatic Glands. These, draining the small intestine, were all greatly enlarged ($\frac{1}{2}$ inch to $1\frac{1}{4}$ inch long), of fleshy consistency, and deep maroon in colour.

Kidneys. Each weighed about 9 oz., and presented no morbid appearances.

Pancreas, ureters, bladder and prostate, healthy. Red marrow of bones, brain and spinal cord were not examined.

Many specimens were taken and sent to Dr. Andrew Balfour for examination.[1]

Smears were taken from liver and spleen, some were sent to Dr. Andrew Balfour and some examined here; and certainly it is a very striking fact that although some twelve hours were spent in examining various smears, in no case could I find anything similar to a Leishman parasite. Further, Dr. Balfour could not find any, though one of the films sent was too thick for proper examination.

There is no doubt that the Leishman parasite was found in smears taken on December 30th, 1907, and Dr. Balfour verified this, his report being, "unmistakable Leishman-Donovan bodies present."

Thus the very important point arises—Did the application of the bio-chemical treatment free the patient from the parasites, though too late to prolong life and procure recovery?

NOTES ON CASE IV

IDRIS ADAM, AGED 26, ARAB POLICEMAN

HISTORY—

Sent to Mafaza, January, 1907.

Lived in police tukls.

Fever started in August, 1907, and then was constantly present except for intervals of five to seven days.

The medical orderly gave him daily quinine, 5–10 grains.

He was sent from Mafaza on January 20th, 1908, and on admission to Kassala Civil Hospital on February 1st, 1908, he was found very emaciated and weak and suffering from fever (*see* Chart, *page* 116).

[1] Unfortunately all the tissues were destroyed in the fire of May 11th.—A.B.

Liver and spleen were considerably enlarged, the conjunctivæ were yellow, and the urine contained bile and a trace of albumen.

The spleen decreased in size under quinine injections, but this drug had no effect on his temperature.

On February 4th, 1908, a spleen puncture was performed, but no parasites found.

On February 19th, 1908, a second splenic puncture was positive, typical "bodies" were found, but in very small numbers.

On February 22nd, 1908, he was started on the atoxyl-fuchsin-sublimate treatment, but though no untoward symptoms appeared, yet there was no improvement. Weakness and emaciation steadily increased, œdema of legs appeared on March 14th, 1908, troublesome and persistent epistaxis on March 22nd, 1908, and he died on March 26th, 1908.

An autopsy was not performed owing to the strong objections of his relations, so it was not possible to prove if the parasites had disappeared from spleen and liver.

It is greatly to be regretted that more autopsies were not performed, but the feeling is so strong against this procedure that it was considered unwise to insist, for undoubtedly by doing so very great harm would have been done to the civil work.

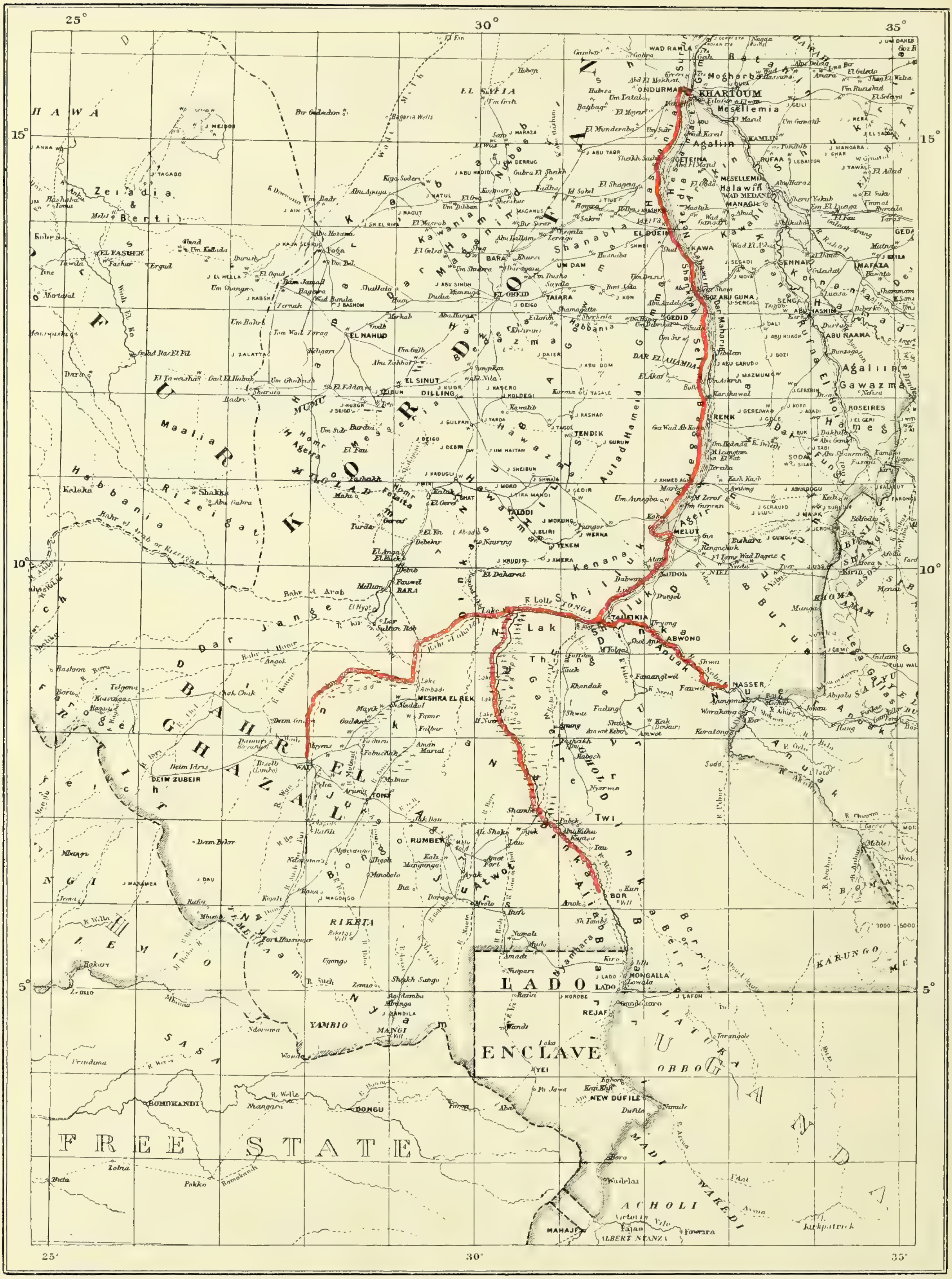


FIG. 28. ROUTE TAKEN BY TRAVELLING PATHOLOGIST AND PROTOZOOLOGIST IN THE FLOATING LABORATORY, 1907-8

ROUTE INDICATED IN RED

Report of Travelling Pathologist and Protozoologist

BY

C. M. Wenyon, M.B., B.S., B.Sc.

Protozoologist to the London School of Tropical Medicine

Introduction

The Floating Laboratory

The idea of a floating laboratory which could be moved up and down the Nile and its tributaries having been conceived by the Director of the Wellcome Research Laboratories, Mr. Wellcome, who had already done so much for scientific investigation in the Sudan, fitted out with every requirement and convenience the two-decked barge built by the Sudan Government for this purpose. The large laboratory, with its two long benches, water taps and sinks, with water supply from a carbon filter on the upper deck, ample cupboard room for bottles and glass ware, the incubators and ovens, the balances and centrifuge, and all other equipment, reminded one more of a laboratory at home than the accommodation one would expect to find on one of the upper tributaries of the Nile in some remote corner of the Sudan. Such a mode of conducting investigation is peculiarly suited to the upper reaches of the Nile and its tributaries, where the larger portion of the population is found along the river banks or within easy reach thereof. The floating laboratory can readily be moved from place to place, and a longer or shorter stay made at any one spot according to the interest and resources of the neighbourhood. Short trips inland can be made, and the material there collected can be more fully investigated on return to the barge.

The advantages of such a laboratory with everything at hand, with solid benches on which to stand one's microscope, with a good supply of clean water, will be sufficiently evident to anyone who has tried to work in a dusty tent with apparatus stowed away in boxes, with the microscope on a rickety table, and with a limited supply of water. The floating laboratory is, as far as I know, the first of its kind; for though boats and other craft have from time to time been temporarily fitted out for scientific work, this is the first time that such a vessel has been built especially for this purpose with accordingly accommodation and conveniences which any adapted boat could not possibly possess. Though further experience may introduce improvements, those who originated the scheme, and those who were far-sighted enough to carry it into effect, are to be congratulated as being the first to introduce this mode of scientific investigation.

Plan of work

The floating laboratory being ready at the beginning of 1907, I went out to the Sudan in March and reached Khartoum on the 14th of the month. I was to remain in the Sudan one year, and to spend my time travelling with the floating laboratory on the upper reaches of the Nile collecting material and making observations according as opportunity arose. It was not the intention that I should investigate any special point, but rather that I should devote my time to making more general observations on the parasitology of man and animals.

Work of a similar nature had been done by Sheffield Neave when he acted as Travelling Pathologist in the years 1905–06. He laboured under much greater difficulties, having to undertake his work in a tent or in a temporarily fitted-up gyassa, conditions which cannot be compared with the comfortable and fully equipped laboratory now on the Nile. I was to follow up and augment the work already begun by Sheffield Neave, whose results appeared in the Second Report from the Wellcome Research Laboratories.

Work in Khartoum

From March 14 to April 15 I remained in Khartoum. This time was partly occupied in studying the flies and other parasites already collected from the Sudan, and also in continuing investigations I had commenced elsewhere on intestinal amœbiasis. For the opportunity of conducting the latter study in the Military Hospital, Khartoum, I am indebted to Colonel G. D. Hunter, Principal Medical Officer of the Sudan, and to the other medical officers of the Staff, who kindly placed their laboratory and cases at my disposal. As a result of this investigation, I was enabled to confirm part of Schaudinn's work on human amœbiasis—the occurrence of amœbæ in persons not suffering from diarrhœa or dysentery, the occurrence of the same amœba in some cases of dysentery and the development of this amœba by the production of cysts of about 14 μ in diameter and containing at first one, then two, four, and finally eight nuclei embedded in a single mass of protoplasm. An amœba reproducing in a similar manner

Human amœbæ

C. M. Wenyon

Fig. [illegible]—Floating Laboratory and Camp at Lo[illegible], on the Jebel River

I found in a monkey. I was, however, unable to determine the presence of Schaudinn's pathogenic *Entamœba histolytica*, which is peculiar to certain cases of dysentery and reproduces by encysting in a totally different manner from the amœba just mentioned.

I left Khartoum for Taufikia on April 15 in company with Dr. Balfour. On the journey to Taufikia Dr. Balfour and I examined for intestinal flagellates, the Seroot fly, *Tabanus socius*, which attacked the floating laboratory in large numbers. At the very commencement the laboratory showed itself to be a veritable fly-trap. The laboratory has a door at each end, while on each side are three windows, over which mosquito-proof gauze frames may be let down. By closing the gauze frames over the windows and leaving the doors open it was found that flies collected on the gauze, and thence could be readily removed for examination or into the killing bottle. Through all my journeyings on the Nile this method of capturing flies was most serviceable, and practically all the flies in my collection were thus entrapped upon the gauze window-frames. There being an excellent mosquito house on the upper deck, it was not necessary to use the laboratory as a mosquito-proof room, and so by the same device of leaving the doors open at night large numbers of mosquitoes were found on the windows in the morning.

The laboratory as a fly-trap

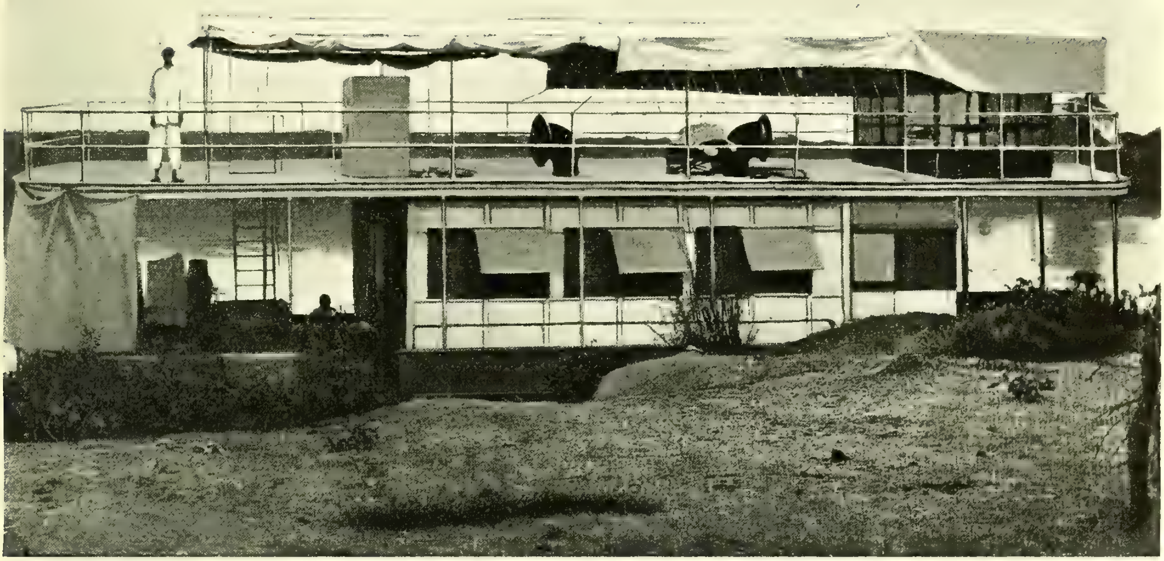


Fig. 30.—Floating Laboratory on the Sobat River

Fig. 31.—General View, Floating Laboratory on Nile
(Auxiliary to the Wellcome Research Laboratories Khartoum)

Herpetomonas in *Tabanus socius*

To return to the dissections of the Seroots which we undertook, Dr. Balfour first found in one *Tabanus socius* large numbers of resting *Herpetomonas*. It was not till I had dissected upwards of fifty or sixty that I came across an infected fly. I continued the dissections of *Tabanus socius*, after arriving at Taufikia, and found there also only a small percentage of flies infected. This was very different from the condition prevailing at Nasser on the Sobat, hardly 100 miles distant, where as many as one fly in every three was infected. I remained at Taufikia from April 23 to June 16. It was during this time that the wet season set in, and much difficulty was occasioned by the leaking of the roof of the laboratory. The leakage was effectually stopped by covering the upper deck with ruberoid material sent up from Khartoum.

Work at Taufikia, White Nile

At Taufikia I found trypanosomes in donkeys and camels returning from the Bahr-El-Ghazal. In the case of the camels only four animals out of seventy-five survived to return to Taufikia, after having been in the Bahr-El-Ghazal Province three to four months, and of the survivors one died shortly after its arrival and in two of the remaining three I found trypanosomes present. Large numbers of animals were examined for blood parasites, with the result that trypanosomes were found in two species of Varanus, the spiny mouse, several fish and toads, while hæmogregarines were found in snakes, lizards and toads, and though many birds were examined only *Halteridium* was present. During my stay at Taufikia, and also on the journey up from Khartoum, I commenced the study of the *Leucocytozoon* discovered by Sheffield Neave in the blood of guinea fowl, and which is of special interest because of its resemblance to the *Leucocytozoon* of the little owl, the life-history of which was studied by Schaudinn.

Work at Nasser, on the Sobat River

I left Taufikia on June 16, and reached Nasser on June 19. Nasser, on the banks of the Sobat, is a large collection of Nuer and Anuak villages near the borders of Abyssinia. As the wet season had set in, the village was surrounded by large stretches of swamp, and accordingly mosquitoes were very numerous. Examination of the blood of the natives revealed a widespread malarial infection. Ten beads were offered to anyone who submitted to having his blood examined, and though at first this was not a sufficient attraction, later on it overcame suspicion and brought large numbers to the floating laboratory. Several hundreds of mosquitoes were dissected, and though malaria was so prevalent, not a single example of plasmodium-infected mosquito was encountered. In one, *Myzomyia nili*, *Herpetomonas* was discovered, and in one *Tæniorhynchus tenax*, encysted nematodes, probably filariæ, were found among the thoracic muscles. In *Tabanidæ*, *Herpetomonas* occurred in *Tabanus socius* as well as in other species. The occurrence of these flagellates in the *Tabanidæ* is of interest in connection with the trypanosomiasis in those districts of the Sudan not infested with *Glossinæ*. On the Sobat, cattle are infected with *Trypanosoma nanum*, and as here no *Glossina* occurs, it is possible that the *Tabanidæ* are concerned in its transmission. However, it must be remembered that *Tabanidæ* are found to be infected in countries where no cattle trypanosomes occur.

Hæmocystidium in a snake

At Nasser, in one of the black spitting cobras, an interesting parasite, which had hitherto only been found in two other hosts, was discovered. This is a pigmented intra-corpuscular parasite named *Hæmocystidium*, which occurs in an Indian river tortoise and lizard, and also in a South African tortoise. In the same snake a trypanosome was discovered. Toads at Nasser were generally infected with filaria.

A storm on the Sobat River

During the whole of my stay at Nasser the weather was very bad, with frequent thunderstorms. The country round was swampy, so that it was impossible to travel much in the neighbourhood, and on many days I was quite unable to leave the barge. In one thunderstorm the floating laboratory only just escaped what might have been a serious disaster. The wind rose with tropical suddenness, and carried away the barge from its moorings and drove it for about a quarter of a mile up the river against the stream, which was then flowing at three or four miles an hour. The floating laboratory fortunately proved itself equal to the test, or it would have sunk with all its equipment to the bottom of the Sobat.

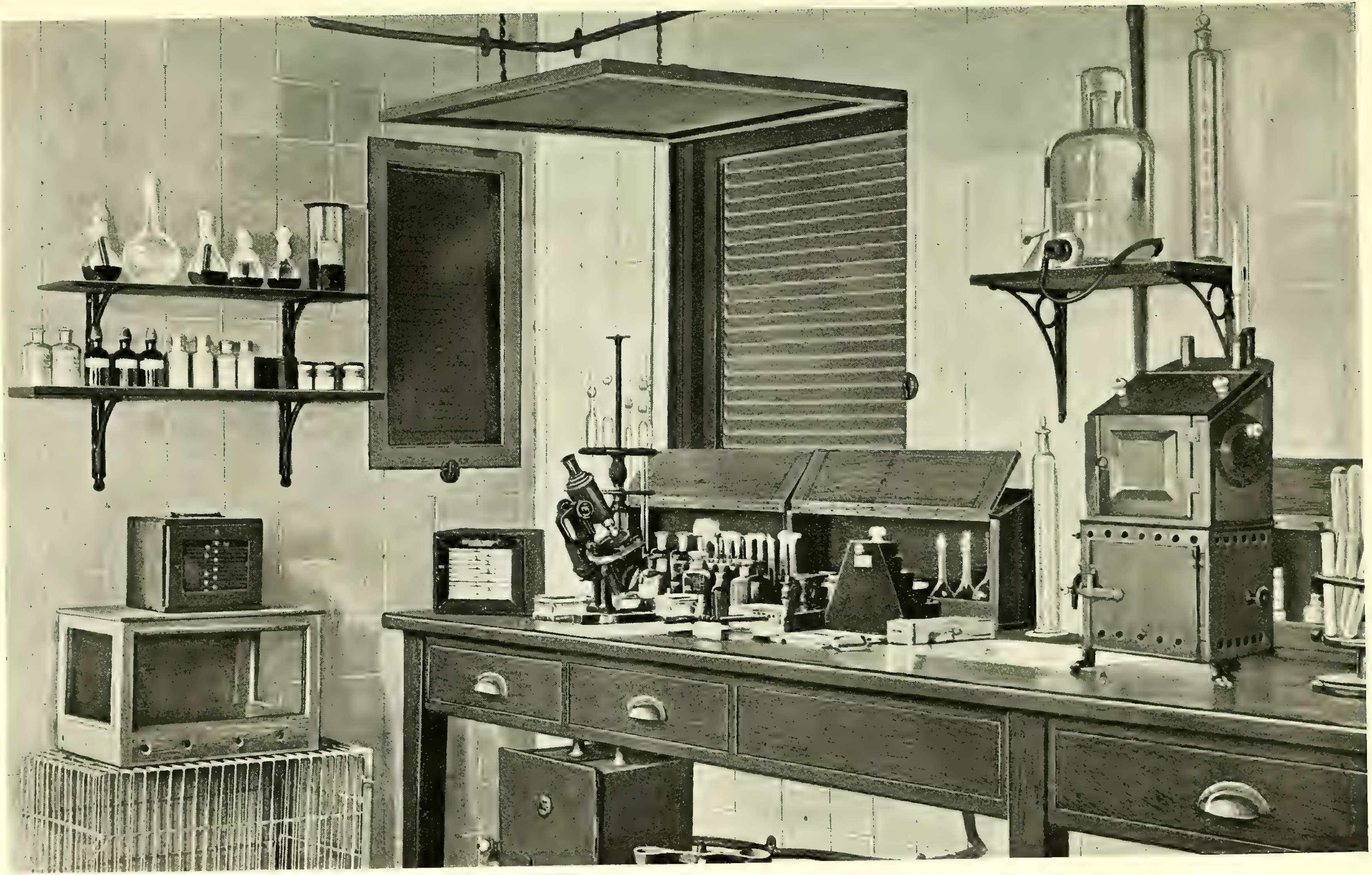


Fig 32.—Part of Bacteriological Section, Floating Laboratory, looking towards bow

At Nasser several of my men contracted malaria of the malignant type, and the inconvenience of this, together with the inclemency of the weather, did not improve one's outlook on this benighted spot. I was not sorry to leave for Wau, in the Bahr-El-Ghazal Province, on July 29. Wau was reached on August 16. On September 4 a short trip of a week's duration was made to a point about ten miles up the Sueh River in the hope that *Glossina morsitans* would there be found. There were no *Glossina morsitans*, however, but each day two or three specimens of *Glossina palpalis* were taken in the floating laboratory. This is the first time that *Glossina palpalis* has been noted from this river. After my return to Wau occasional specimens of this fly were taken there. Two or three years ago Captain Ensor reported having taken a single example of *G. palpalis* in Wau, but as he had just returned from a fly district there was the possibility that the fly had been imported in his baggage. Evidently *Glossina palpalis* occurs in and around Wau and along the Sueh River. In Wau itself I did not meet with *Glossina morsitans*. Here trypanosomes occurred in numbers of cattle and transport animals, but according to the distribution of *Glossina morsitans* animals remaining in Wau apparently did not become infected with *Trypanosoma pecaudi*, and only contracted this form of trypanosomiasis if they were taken out of Wau to a district infected with *Glossina morsitans*. *Glossina palpalis* occurring in Wau were either there in insufficient numbers or were incapable of transmitting the malady.

Work at Wau, on the Jur River

At the hospital at Wau numbers of cases of guinea worm were admitted for treatment. Advantage was taken of this to conduct some experiments. Cyclops could be obtained in good numbers in the pools in and around Wau, and these I infected with the guinea worm embryos. The embryos seem to enter the cyclops "tail first" by first penetrating the cuticle of the cyclops with their sharp extremities. I was able to confirm the observations of Leiper that after the embryo had completed its metamorphosis and become quiescent within the body of the cyclops, addition of 0·2 per cent. solution of hydrochloric acid killed the cyclops but had the opposite effect on the metamorphosed embryo, which began to wriggle about and finally escaped from the dead body of its host, thus bearing out the conjecture that man becomes infected by taking in cyclops in drinking water, the experiment with the acid being repeated in the stomach. I was unfortunately unable to feed monkeys on infected cyclops owing to the untimely death of all my material.

Experiments on guinea worm infection

Trypanosomes were found in two species of lizard in Wau, and two interesting pigmented intra-corpuscular blood parasites also in lizards. While in Wau all my men had malaria at one time and another in spite of the administration of quinine every tenth and eleventh day. I myself likewise became infected at this place.

Owing to an unprecedented fall in the Jur River I was compelled to leave Wau earlier than I intended, and thus much of the work I had in hand there was suddenly cut short. The floating laboratory accordingly commenced to drift down the Jur River on October 10.

After much difficulty, caused by the presence of the sudd in the Bahr-El-Ghazal, the main Nile was reached on November 3, and Barboi Wood Station on the evening of the same day.

Work at Barboi, White Nile

A stay of about one month was made at the Wood Station, and then a short trip of a few days was taken to the American Mission Station at Doleib Hill on the Sobat, where the Shilluk cattle were dying off rapidly. The cattle I found to be suffering from *Trypanosoma nanum* infection, and also two kinds of Piroplasma, viz.: *Piroplasma mutans* and *Piroplasma bigeminum*. On December 5 the Sobat was left for Bor on the Jebel River, which was reached on December 10.

During my stay here I examined large numbers of cattle, but found parasites only in one, viz. a cow, which was passing through Bor on its way from Uganda, which it had left two days before. It was suffering from *Trypanosoma nanum* and also *Piroplasma mutans*. *Trypanosoma nanum* infection would thus appear to be of extensive distribution, being found

C. M. Wenyon

Fig. 33. Part of Interior of Floating Laboratory, looking towards stern

G. Morris

Fig. 34.—Part of Interior of Floating Laboratory, looking towards stern (another view)

Work at Bor, Bahr-El-Jebel or Upper White Nile

on the Sobat, in the Bahr-El-Ghazal Province, and also in Uganda. At Bor several new blood parasites were found, including a new form of Piroplasma in the zebra mouse.

On January 31 the floating laboratory travelled North from Bor with the object of revisiting the Sobat. A stay of about a fortnight was made at the Mission Station, too short a time to thoroughly investigate the epidemic then prevailing amongst the cattle. I found, however, that dogs could be inoculated with *T. nanum*, though rats were practically always refractory. The infection proved fatal to dogs. I was unable to determine the transmitting agent.

Fowl spirillosis

At Meshra-El-Rek, at Bor, and on one of the steamers running between Khartoum and Gondokoro, I saw chickens suffering from spirillosis. It would appear that this disease of fowls is very widespread throughout the Sudan. In a guinea fowl which died I found the peculiar intra-corpuscular bodies described by Dr. Balfour in the present volume as occurring in the blood of chickens which have suffered from an attack of spirillosis. Dr. Balfour has found that these bodies are derived from spirochætes which have penetrated the corpuscles. It is evident, then, that guinea fowl are susceptible to chicken spirillosis. At Khartoum and elsewhere cattle were infected with sarcosporidia, while a curious eruption of white nodules on the ears of a wild rat was found to be due to one of the sarcosporidia.

Return journey

The return journey was commenced on February 16, and after a few days' stay in Khartoum I left for home, reaching London on March 22, after an absence of a year and twenty-two days.

The foregoing is a brief outline of the course taken by the floating laboratory on the Sobat and Jebel and in the Bahr-El-Ghazal Province, and the nature of the investigations undertaken. It will be seen that these are of a general nature, the length of stay at each place being too short for thoroughly investigating any one point. This plan was adopted as the Sudan is a comparatively new country, and it was desirable to investigate the distribution of trypanosomiasis, piroplasmosis, and other similar conditions. In the following pages will be described in greater detail the results I have obtained.

Acknowledgments

Before entering on this part of my report I must take this opportunity of expressing my indebtedness to all those who have assisted me in my work in the Sudan. Wherever I have travelled on the Nile and wherever I have come in contact with them I have found the Government officials most willing to help me in every way, and many have put themselves to considerable trouble in order to render me assistance. I must not omit to mention my obligation to the Staff of the American Mission on the Sobat, who did much to facilitate my investigation of the cattle disease before mentioned.

My thanks are also due to Doctor Werner, who has identified reptiles and amphibia; Professor Nuttall, who has identified ticks; and Mr. Butler, Director of the Game Preservation Department in the Sudan, who identified birds and small mammals. Doctor Werner has written a report on the reptiles collected by me, and this is included in the present volume. Dr. Leiper, Helminthologist to the London School of Tropical Medicine, has described the collection of Helminthes (*see page* 187).

Human Conditions

Dysentery

Detailed report, dysentery

While at Khartoum and later at Taufikia I conducted some investigations on the intestinal amœbæ of man. On no occasion was I successful in finding an amœba corresponding to Schaudinn's *Entamœba histolytica*, which is said by him to be the occasional cause of dysentery. Amœbæ corresponding with his *Entamœba coli* were met with both in dysentery cases and in cases which appeared quite normal. Schaudinn gave certain morphological appearances which were characteristic of these amœbæ and by which they could be distinguished from one another. I found, however, that in healthy individuals the amœbæ might show features characteristic of Schaudinn's dysentery amœba, *Entamœba histolytica*, and, *vice versâ*, in true dysenterics the amœbæ might correspond completely with Schaudinn's harmless *Entamœba coli*. It is fortunate for us that there are other more definite means of distinguishing these amœbæ. According to Schaudinn, *Entamœba histolytica* produces cysts, which are small, measuring only 3 to 7 μ in diameter. These cysts have a tough membrane which obscures the contents. On the other hand, *Entamœba coli* produces cysts having a diameter of about 14 μ. The membrane enclosing them is clear and transparent, so that the contents are easily visible. It is quite evident that the differences between the cysts are such that they can be readily differentiated. However, I have been unable to discover the small cysts of *Entamœba histolytica* in any dysentery case I have examined. I have repeatedly found the cysts of *Entamœba coli* in both dysentery cases and in healthy individuals. Schaudinn says that in only a small percentage of dysentery cases is *Entamœba histolytica* the exciting cause, so it is possible that I have not examined a case in which this amœba is present. The presence of *Entamœba coli* in dysentery cases is only to be expected when it is known that it may also occur in healthy persons. Its presence is only accidental and has no bearing on the course of the disease.

Work on *E. histolytica* *E. coli*

Schaudinn described in detail the life-history of *Entamœba coli* and the development of the cysts. I have shown elsewhere that the development of the amœba living in the intestine of mice follows an almost identical course, so much so that it seems very probable that the amœba of the mouse and that of man are identical, and possibly also the amœbæ of other animals. This opens up the question of domestic animals acting as alternative hosts for the amœba found in the human intestine.

I have not been able to trace every stage in the development of the cysts of *Entamœba coli* from man; but I have seen a sufficient number of different stages, and these correspond so closely with Schaudinn's description and my own findings in the case of the amœba of mice that there can be little doubt that the development described by Schaudinn is the correct one.

Stages in the development of *E. coli*

In this development an amœba becomes freed of all food particles, which are thrown out from the body, and then contracts to a spherical shape. Around this spherical mass of protoplasm, which contains a single nucleus, there forms a thick gelatinous covering which quickly contracts to a tough transparent envelope. The single nucleus divides into two, and within the tough envelope there forms a thin membranous second covering to the encysted amœba. There are now two nuclei situated at opposite poles of the cyst. Each nucleus now divides twice to give off two reduction bodies, which degenerate. The two remaining nuclei, which are now smaller and poorer in chromatin, divide again, so that there are two pairs of nuclei lying at opposite poles of the cyst. One nucleus in each pair begins to move away from the other, which remains stationary. The moving nucleus of each pair crosses over to the opposite side, where it comes in contact with the stationary nucleus, finally fusing with it. In this way there is brought about an interchange of nuclear material between the two nuclei. After conjugation a stage with two nuclei is again reached. Each of these nuclei divides to produce a cyst with four nuclei, and each of these four to give eight nuclei.

At this stage there is a cyst containing a single mass of protoplasm in which are embedded eight small nuclei. No further development takes place till after the cyst has escaped from the body. These cysts can withstand drying, and could be carried about by wind and water. When taken into the intestine of a new host the mass of protoplasm within the cyst divides into eight small amœbæ, which escape by the rupture of the cyst and so infect the new host.

In the human intestine it is common to meet with cysts containing two, four, or eight nuclei. These are merely different stages in the development. In the two-nuclei stage there is often contained within the protoplasm a refractile body which is sometimes so large as to nearly fill the cyst, reducing the protoplasm to a thin layer. This body was referred to by Schaudinn, and I have met with it in the cysts of the mouse amœba and also in the cysts of *Entamœba coli.* As development proceeds this body breaks up into fragments, which appear to shrink but never completely disappear. Cysts of an amœba indistinguishable from those of *Entamœba coli* I found in the intestine of a monkey which died in the Wellcome Research Laboratories at Khartoum.

Four stages of cyst of *E. coli*

In Fig. 35 are shown drawings of four different stages of the cysts of *Entamœba coli* which were met with in the examination of cases at the military hospital at Khartoum. A represents the just encysted amœba with the gelatinous covering and a single nucleus. B is the next stage with two nuclei. The large refractile body referred to above is also present. The gelatinous covering has contracted to a tough transparent envelope. C shows the cyst with four nuclei. Between the stages shown in B and C the sexual process would take place. D is the stage with eight nuclei and the final stage of development before escape from the body. Further development of these cysts takes place when they are eaten by a new host. The protoplasm divides into eight small amœbæ, which escape and infect the intestine.

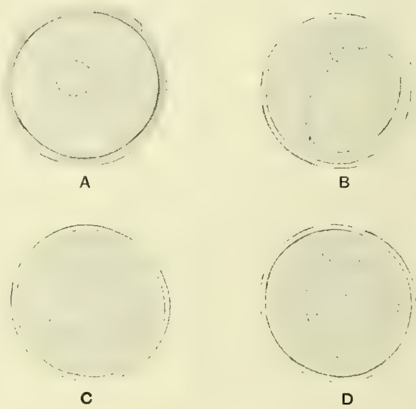


Fig. 35.—Cyst of "Entamœba coli," from a case in the Khartoum Military Hospital

× 1500 *diam*

Malaria in the Southern Sudan

Malaria was found in all parts of the Southern Sudan. The types most frequently encountered were the benign tertian and malignant varieties. Only on one occasion was the quartan parasite seen. At Nasser, on the Sobat, malaria was constant among the small children. In older children it was difficult to find, while in the adults who were true natives of the district I never found it. In adults who had come to live in the neighbourhood from as far north as Khartoum, malarial infection was common. The mosquito which was probably the carrier of malaria at Nasser was *Myzomyia nili*, as it occurred in large numbers. Dissections of these and other species gave only negative results. Leprosy, Mycetoma, and Ainhum were seen especially at Bor. Lesions resulting from Leprosy and Mycetoma are illustrated in Figs. 36–38 on page 131. Syphilis was common, and in several cases of what appeared to be secondary syphilitic eruptions on children about the age of ten, spirochætes, indistinguishable from *Treponema pallidum*, were found. It is very probable that such cases of syphilis are of extra-genital origin, and that this kind of syphilis is more common than one imagines in such countries as the Sudan, where the habits of the people lead them to crowd together into a small space for sleep, with their bodies unprotected by any covering from contact with any one among them who may already be infected. Attention has recently been drawn to the probability of a similar condition existing in other places.

Negative results of mosquito dissections

Prevalence of syphilis

Remarkable case of eosinophilia

At Nasser a remarkable case of eosinophilia was seen in a man who was suffering from a chronic skin eruption on the lower half of his body. The eruption took the form of localised thickenings of the skin, causing it to feel hard and rough. There was much irritation, as shown by the constant scratching and the presence of scabs. The man stated he had suffered from this disease for six or seven years. What the nature of the eruption might be I could form no opinion, unless it was some kind of chronic urticaria. An examination of the blood

C. M. Wenyon

Fig. 36.—Leprosy. Anæsthetic Patches

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Fig. 37.—Mycetoma of Foot. Early Stage

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Fig. 38.—Mycetoma of Foot. Late Stage

showed that 70·4 per cent. of the leucocytes were eosinophiles. The presence or otherwise of ankylostomes was not determined. There was a considerable degree of anæmia. In the Bahr-El-Ghazal a case of blackwater-fever was seen, but this revealed nothing further than the presence of malarial parasites of the malignant variety. Guinea worm was seen at several places, and is more fully discussed in the next section. During the examination of the stools of cases in the Military Hospital, Khartoum, eggs of bilharzia were repeatedly encountered. Both the terminal and lateral spined eggs were found.

Dracontiasis

Dracontiasis

Guinea Worm

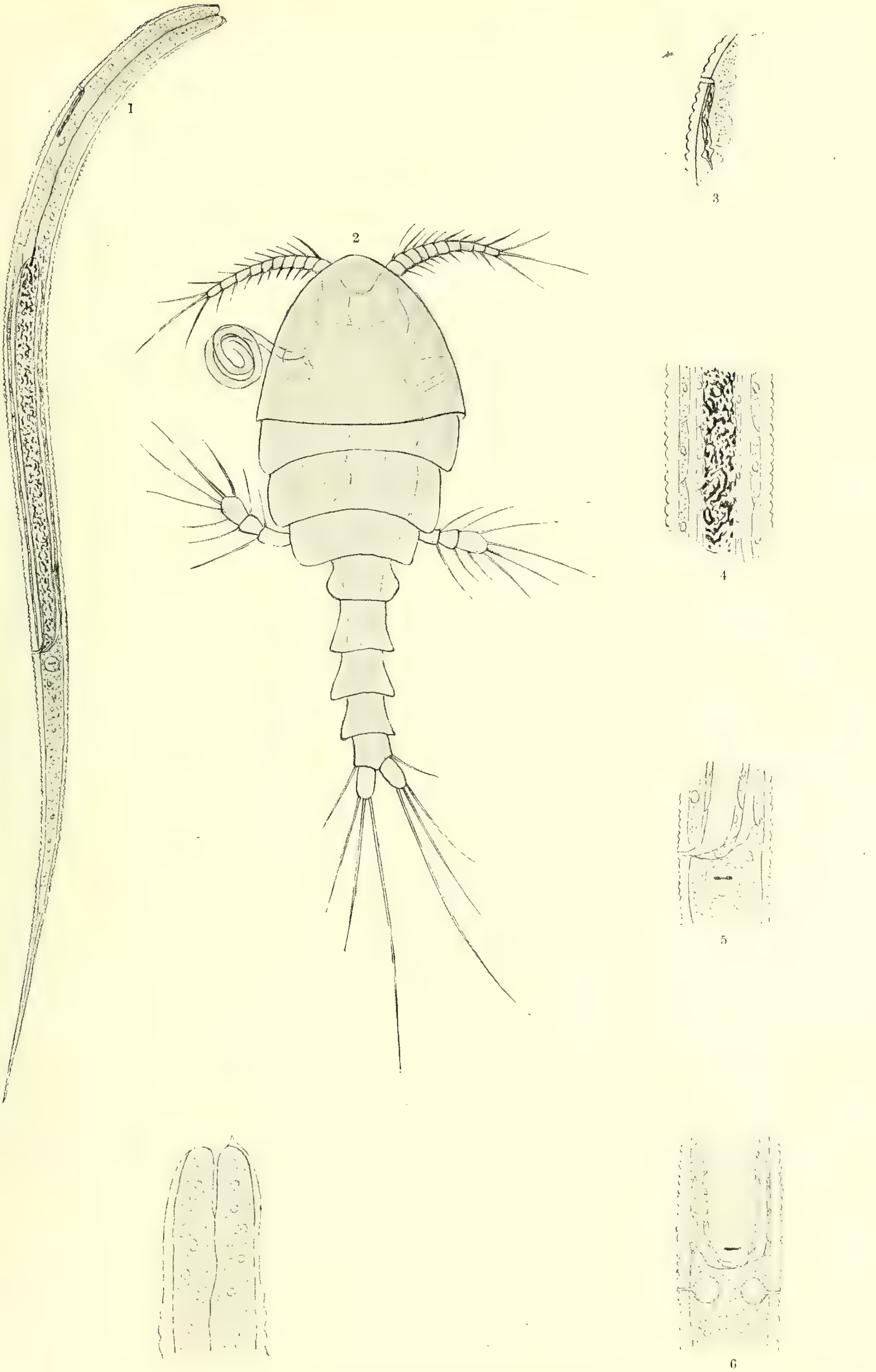
Plate IX., figs. 1–7

Guinea-worm infection common at Wau

At Wau, in the Bahr-El-Ghazal Province, cases of guinea worm infection were common, and, owing to the kindness of Capt. M. G. Dill, then in charge of the Military Hospital, many cases of this disease were at my disposal, and I was able to conduct some experiments which confirm the results obtained by Dr. Leiper. Further, owing to a new method of fixation and staining, I was able to make out some new points in the anatomy of the guinea worm embryos. For the fixation of the embryos the following method was adopted. The active embryos from a guinea worm were placed in a test-tube containing about 1 c.c. of normal salt solution. The tube was then nearly filled with saturated solution of corrosive sublimate. This killed the embryos and fixed them in a few minutes. The contents of the tube were then centrifugalised for about a minute and the supernatant fluid removed. Distilled water was added, the tube gently shaken and again centrifugalised. By repeating this process four or five times nearly all the sublimate was removed. The tube was then filled with 70 per cent. alcohol to which a few drops of iodine solution were added. The tube was left standing upright, with the result that the embryos settled to the bottom. After five or six hours, the fluid was removed by means of a pipette and fresh 70 per cent. alcohol and iodine added. After this had acted for a similar period it was removed and 70 per cent. alcohol alone added. To this was added one drop of Delafield's hæmatoxylin and the tube put aside. By taking out a little of the sediment from time to time the progress of the staining could be watched. The staining of the embryos is slow, owing to the thick cuticle which covers them. It first commences in the region of the anus and of the gland-like organ which opens near the anterior end of the body. After about a week the whole embryo is stained, apparently by the stain gaining entrance by the natural apertures of the body. If the embryos appear not to stain, another drop of hæmatoxylin can be added. If too deeply stained, differentiation may be effected with 70 per cent. acid alcohol by removing the stain and filling up the tube with the acid alcohol, allowing the embryos to settle to the bottom and examining the sediment from time to time. When differentiation is complete remove the acid alcohol with a pipette and replace by ordinary 70 per cent. alcohol. If acid alcohol has been used, a drop of ammonia solution added to the 70 per cent. alcohol will "blue" the embryos. By adding glycerine to the contents of the tube, a drop at a time, the embryos may be thus transferred to a more convenient medium. Between each drop the tube must be gently shaken and allowed to stand about a quarter of an hour before the addition of another drop. The glycerine must not be made too strong nor added too rapidly, or shrinking of the embryos will result. Glycerine added to about 25 per cent. will be quite sufficient. In this medium the embryos may be readily examined with high powers by sealing the edges of the cover slips with paraffin or other fixative. This method has the

Technique employed in studying embryos

PLATE IX



1. × *approx.* 300 *diam.*; 2. × *approx.* 85 *diam.* 3–7. × *approx.* 1000 *diam.*

ANATOMY OF GUINEA WORM EMBRYO

1. General anatomy of guinea worm embryo
2. Cyclops, showing entry of a guinea worm embryo on left
3. Organ opening on ventral surface near anterior end of body. Probably developing excretory system
4. View of middle region of body, showing body and gut-wall and space between these
5. Side view at region of anus
6. Ventral view at region of anus
7. Anterior end of body

disadvantage of being somewhat tedious, but the results cannot be obtained by any rapid method, as the embryos so readily shrink and staining through the cuticle is difficult.

Morphology of embryos, new points

Prepared in this manner the following points can be made out (Plate IX., fig. 1). There is an alimentary canal opening at the anterior end at the mouth, and on the ventral surface near the posterior end in a distinct anus. The opening of the anus is a transverse slit on the summit of a slight elevation (Plate IX., figs. 5 and 6). The anterior part of the alimentary canal is narrow and its wall and the body wall in this region seem to be contiguous. Behind this the canal widens out and its wall is much thinner. In this region there is a distinct space between the body wall and the intestine. This cavity is not lined by epithelium, but is merely a space between the single layer of cells forming the body wall and the similar layer forming the wall of the intestine (Plate IX., fig. 4). This space, which is not a true cœlom but which is similar to the space found in other nematodes, is not continued behind the anus, and I was unable to trace it forwards round the œsophageal portion of the gut (Plate IX., figs. 5 and 6). The intestine is filled with some granular material, which is often seen escaping from the anus and which stains a deep blue with the hæmatoxylin. Near the anterior end on the ventral surface is a second opening (Plate IX., figs. 1, 3). This is found to be connected with an elongated granular structure which runs backwards for some distance under the cuticle and which stains a deep blue. Often some dark staining material can be seen escaping from the opening. Dr. Leiper informs me that this is probably the developing excretory system. As far as I am aware, this body has not hitherto been described. The pointed tail is filled with a solid mass of cells in which are embedded two spherical structures each opening by a distinct pore on the sides of the body just behind the anus. Plate IX., fig. 5, shows a view of this region from the right side with only one of these bodies in view. Its opening is slit-like and often wider at each end than at the middle, so that it reminds one of an elongated figure 8. From the ventral surface these bodies are shown in Plate IX., fig. 6. I was unable to make out any structure in these bodies apart from a granular material.

Experiments with Cyclops

Experiments with cyclops

In the neighbourhood of Wau cyclops could easily be obtained, and these were readily infected with guinea-worm embryos by placing them in a watch glass together. From these observations it would appear that the embryos gain entrance to the body by piercing it with their sharp tails, as a result of their characteristic springy movements, in which the body alternately coils up and straightens out. After the cuticle of the cyclops is pierced the continued movement of the embryo's body completes the entrance. It must be stated that in no instance was a single embryo followed through the whole course of its entrance, but on several occasions different ones were seen at varying stages. In Plate IX., fig. 2, is depicted a cyclops with an embryo entering in this manner. This is a drawing made from a preparation in canada balsam, so that there cannot be any doubt that the embryo has in reality perforated the cuticle and is not merely lying beneath the cyclops.

Confirmation of Leiper's work

After entering the body the behaviour of the embryos was exactly that described by Dr. Leiper. In about six or seven days the movements of the embryos, which had been diminishing during this period, ceased altogether. Apparently the number of embryos entering each cyclops was limited only by its capacity. The cyclops frequently died from the effects of their infection. When the embryos had reached the stage of quiescence their activities were at once renewed by placing them in ·2 per cent. HCl solution, which had the effect of killing the cyclops after a few minutes. The movements of the embryos increased till finally they ruptured the body of the host at some spot and escaped to the exterior, where they remained active for an hour or more. These escaped embryos were of the same dimensions as the original ones which entered, but they were altered in other respects. The same organs were present, but the long pointed tail was lost and replaced by what in side view appeared to be a short blunt tail terminating in two lobes, the ventral lobe being larger and continued further back than the dorsal. Within the body of the cyclops I was not able to make out the presence of any membrane or sheath enclosing the embryos. These observations confirm in every essential point the results obtained by Dr. Leiper. I was unfortunately prevented from feeding monkeys with infected cyclops owing to the untimely death of all my material, and the early fall in the Jur River which necessitated my leaving Wau earlier than I had intended.

At Nasser, on the Sobat, and again at Bor, on the Jebel, I saw single cases of guinea worm, but these gave only dead embryos, which of course were useless for experimental purposes.

Trypanosomiasis in Domestic Animals

Camels

Trypanosomiasis in domestic animals

I first saw trypanosomiasis in camels returning from the Bahr-El-Ghazal Province in April. Four camels survived to return to Taufikia out of about seventy which had left Khartoum for telegraphic transport three or four months before. After leaving the river the following route had been followed in the Bahr-El-Ghazal Province—Shektombi to Alyab, thence along telegraphic line to M'volo, from there to Rumbek and back to the river at Shambe. The first of the camels died at Bufi between M'volo and Shektombi. The majority died at Shambe, after the transport work was finished. What information I could get as to the biting flies that attacked the camels was too indefinite to be of use. Judging from the four camels that survived to return to Taufikia, three of which revealed trypanosomes on blood examination, it is probable that all the camels died of trypanosomiasis. In the same transport the donkeys and mules suffered, but to a less extent. Of these animals about 25 per cent. died probably from the same cause. I was, however, unable to examine any of the surviving donkeys and mules.

Trypanosomiasis in camels in the Bahr-El-Ghazal

The much higher death rate among the camels is due probably to the fact that these animals are not indigenous to this part of the Bahr-El-Ghazal Province, and that they are brought in to do special work and prove to be highly susceptible.

The country consists of grass-land, bush, swamp, and river, and is naturally unsuitable for camels. The death-rate is always high, but the camels survive long enough to carry out the work for which they were introduced. Trypanosomiasis in the case of these animals is of quite a different nature to the trypanosomiasis occurring in camels in countries where camels are indigenous. In the case of donkeys and mules—animals which are commonly seen in this part of the Bahr-El-Ghazal—the trypanosomes found in the blood of infected animals are of the *Trypanosoma pecaudi* type, and one would expect that camels becoming infected in the same district would show the same trypanosome. In the case of the camels at present under discussion, unfortunately, no experimental animals were inoculated, but the various forms of the trypanosome found in the stained blood films are figured in Plate X., figs. 10–14. Morphologically there are some differences between this trypanosome and the forms met with in the blood of donkeys (Plate I., fig. 1) and other animals, but these are only slight variations. The broad forms (Plate X., fig. 12) are not so broad, and the long forms (figs. 11 and 14) have a shorter free flagellum. The three main types occur, however, in both cases—viz., the small tadpole forms (fig. 10), the broad forms (fig. 12), and the long form with free flagellum (fig. 14). The vacuole situated near the micronucleus which is so characteristic of the trypanosomes as they occur in other animals is found here also, so that I would suggest that the slight morphological differences are merely due to the difference in the host

This camel trypanosome probably *T. pecaudi*

and that this trypanosome is in reality *Trypanosoma pecaudi* which occurs in other animals in the same district.[1]

Donkeys and Mules

The disease in donkeys and mules

In donkeys and mules the trypanosome described by Dr. Balfour in the Second Report of the Wellcome Research Laboratories was encountered on several occasions. I first saw it in a donkey at Taufikia which had come down from the Bahr-El-Ghazal Province. By inoculation of rats I was able to keep this strain of trypanosomes during the whole time I was in the Sudan. As a rule the animals became infected in five or six days and lived about one month after infection. On no occasion did I find a rat refractory to inoculation. Through all these passages the trypanosomes retained their original form, the three main types which have been mentioned above as occurring in the case of camels seen at Taufikia being always evident. The majority of the trypanosomes are of the two types described by Laveran, but in addition there occurs also, but in much smaller numbers, a short form very much like *T. nanum.* This form may be no more than 12μ in total length, and has no free flagellum or one that is very short, is indistinguishable from the forms of *T. nanum,* and corresponds with the "tadpole" forms of *T. dimorphon* described by Dutton and Todd and others.

The three forms that I have met with are:

1. Long forms resembling *T. Evansi.*

The trypanosome concerned probably *T. pecaudi*

2. Forms without free flagella and measuring about 14μ. Nucleus may be central or anywhere between this point and close up to the micronucleus. Very commonly a vacuole is seen lying against the micronucleus. The membrane is very wide, the total width of body, including the membrane, from 4 to $4{\cdot}5\mu$. Body may be very granular between the nucleus and flagellar extremity.

3. Forms with no free flagella or ones that are very short, nucleus centrally placed, undulating membrane little developed. Total length about 12 to 14μ. Very closely resembling *Trypanosoma nanum.*

These three forms have been mentioned in Dr. Balfour's account of this trypanosome. They are figured in Plate I., figs. 1 and 3. In his account in the last volume of the Reports Dr. Balfour inclined to the view that this trypanosome was *T. dimorphon* of Dutton and Todd, but he is now of the opinion that it is more probably *T. pecaudi.* This latter view is in all probability the correct one.

Tsetse flies at Wau

The distribution of *Glossina* in and around Wau is of interest. In Wau itself I did not encounter *Glossina morsitans*, but *Glossina palpalis* occurred regularly in small numbers. On the Wau river, about five miles from Wau, *Glossina morsitans* first appeared. Animals remaining in Wau did not become infected with trypanosomes, but after a short trip outside Wau they frequently became infected. A mule which had remained perfectly healthy in Wau for a year or more was taken across the Wau River for two or three days and there contracted trypanosomiasis, from which it died a month later. This animal, though it was stabled with other mules and donkeys, did not become a centre for a general infection. This may have been due to the absence of *Glossina morsitans* in Wau, and that *Glossina palpalis* was unable to transmit this trypanosome or was present in too small numbers. Experiments with *Glossina palpalis* and infected rats gave only negative results, even when the fly was fed on a healthy rat directly after feeding on one whose blood was swarming with trypanosomes.

[1] This trypanosome resembles in many respects *T. dimorphon* of Dutton and Todd and also *T. pecaudi.* The identity of this trypanosome with either of these is discussed by Dr. Balfour in this volume of the Report, with the result that he decides for the *T. pecaudi* view. In my account I shall speak of his trypanosome therefore as *T. pecaudi.*

These remarks have reference to *Trypanosoma pecaudi.* It is interesting to remember that positive results have been obtained by Roubaud and Dutton, Todd and Hanington working with *Trypanosoma dimorphon* and *Glossina palpalis.* *Trypanosoma nanum,* which occurs regularly in Wau and is responsible for the death of large numbers of donkeys, belongs to another category. In its transmission *Glossina* may have no share, as the trypanosome is found in districts where the fly is never seen.

Trypanosoma nanum was named and described by Laveran from films sent to him by Dr. Balfour in 1905. The appearances of this trypanosome in the fresh blood have been well described by Dr. Balfour in the last volume of the Reports, and the stained specimens by Laveran. From examination of a large number of specimens, I should say there are two main types of this trypanosome:

T. nanum of cattle

1. Forms measuring from 10 to 15μ with no free flagellum, undulating membrane straight and difficult to bring out in stained specimens—resemble tadpole forms of *T. dimorphon.*

2. Forms measuring about 20μ, 5μ of which are taken up by the free flagellum.

Between these two types are intermediate forms. All these are shown at Fig. 39.

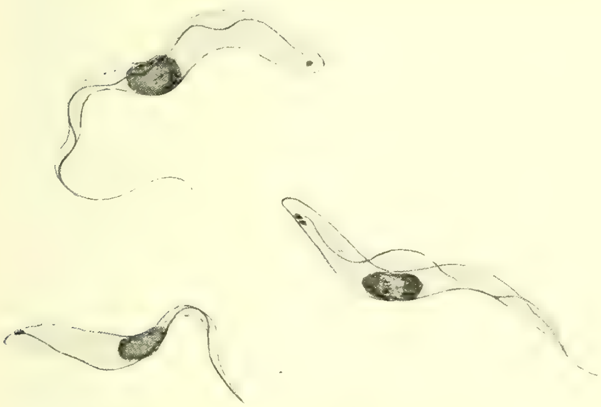


Fig. 39.—Three Forms of "Trypanosoma nanum."

[× 2500 *diam.*

These findings correspond closely with the descriptions of this trypanosome by Dr. Balfour and Prof. Laveran.

Form with free flagellum

I came across this trypanosome in cattle on the Sobat at the American Mission Station, in cattle at Wau, in the Bahr-El-Ghazal Province, and at Bor in a dying cow which had left Uganda two days before. The condition of this cow does not admit of the possibility of its having been infected after entering the Sudan. *Trypanosoma nanum* has, therefore, a wide distribution through the Southern Sudan and even into Uganda. Further observation will probably extend the limits of its distribution.

The short trypanosome of mules probably *T. nanum*

A trypanosome resembling *T. nanum* was found by Dr. Balfour in mules, and mentioned by him in the Second Report (*page* 172). This trypanosome I found in mules at Wau, and also in donkeys at the same place. I think there can be little doubt that this trypanosome is identical with *T. nanum* of cattle. The disease produced in cattle and in the donkeys and mules is the same—viz., a slow wasting, ultimately ending in death.[1] The trypanosomes are never very numerous in the blood, there being rarely as many as one trypanosome to every three or four fields of the microscope. More usually it takes several minutes' search on a stained film to find a single example. In all these animals the trypanosomes have the same characters, and further inoculation of rats from either cattle or donkeys is practically always followed by negative results. Fifteen rats were inoculated either from cattle or donkeys infected with the small trypanosome, and in only one case (from a cow) was an infection produced, and that after sixteen days' incubation period. This rat unfortunately died unexpectedly, and the strain was lost. From mules rat inoculations were not made, but Dr. Balfour has been able to carry on a strain from a mule by inoculation in gerbils. From a heifer suffering from this disease on the Sobat I inoculated two young dogs. One of

[1] Recovery can certainly take place in the case of cattle.—A.B.

these became infected in twelve days and the other in fifteen days. These two dogs were left at the Wellcome Laboratories when I returned to England. One died later from the infection, while the other perished in the fire which broke out at the Laboratories. From one of the infected dogs a gerbil was inoculated by Dr. Balfour, with a positive result. It will thus be seen that positive results have been obtained in gerbils by Dr. Balfour by inoculation from the mule and also from the dog which had been infected with trypanosomes from a cow. It would appear that rats are resistent to inoculations with *Trypanosoma nanum*, while dogs and gerbils are susceptible. From the evidence brought forward, I think it is clear that the small trypanosome found in mules and donkeys in the Bahr-El-Ghazal Province is no other than *Trypanosoma nanum*.

T. nanum probably not a form of *T. dimorphon*

In their paper entitled "Cattle Trypanosomiasis in the Congo Free State," Dutton, Todd, and Kinghorn, in discussing *T. nanum*, say: "Is it not possible that further work on this parasite may show that it is merely the tadpole form of *T. dimorphon*?" I do not think this likely, for *T. nanum* in the Sudan is found along the Sobat, where *Glossina* does not occur, while *T. pecaudi* is only found in *Glossina*-infected areas. (*T. pecaudi* is the Sudan representative of *T. dimorphon*. The two may be merely variations of one trypanosome.) The symptoms produced in animals by *T. nanum* differ from those produced by *T. pecaudi*. Animals artificially infected with *T. nanum* (one rat and two dogs) show characteristic small trypanosomes in their blood. There is no tendency for the trypanosomes to assume the *T. pecaudi* form and *vice versa*. *T. pecaudi*, easily inoculable into rats, retains its characteristic form throughout all passages. It must be remembered that *T. nanum* does occur in districts where *T. pecaudi* is found, so that one must not lose sight of the possibility of a double infection; but in Wau donkeys and mules remaining in or near the town became infected with *T. nanum* alone, but the same animals (uninfected with *T. nanum*) taken to a *Glossina morsitans* district at once contracted typical *T. pecaudi*, from which they rapidly died. It is possible for an animal to be infected with *T. pecaudi* and have in its blood the tadpole forms of this trypanosome while at the same time it is infected with *T. nanum*. In such a case the tadpole forms of *T. pecaudi* would be indistinguishable from *T. nanum*. I do not think it probable that *T. nanum* is the tadpole form of *T. dimorphon*, though the reverse might be true that the tadpole form of *T. dimorphon* is really *T. nanum*. In a district in which both these trypanosomes are found confusion of the two must occur, at least sometimes. From my observations in the Sudan I feel convinced that *T. nanum* is a definite entity distinct from *T. pecaudi* or *T. dimorphon*.

T. nanum a distinct species

On the Sobat I conducted some experiments to determine the mode of transmission of this trypanosome, but owing to the fact that I did not discover that dogs were susceptible till after I left I obtained no definite results. The Sobat cattle are not liable to bites from *Glossina*, as this fly is not found here. Various *Tabanidæ*, *Stomoxys*, *Hippoboscidæ* and ticks (*Rhipicephalus sanguineus*, *R. evertsi*, *Boophilus australis*, *Amblyomma* sp.) attack the animals. Numbers of ticks were made to feed on rats with no result, but this is hardly to be wondered at when one considers the resistance of these animals to *T. nanum* inoculation. Experiments with gerbils or young dogs would be more likely to give results. In the intestine of ticks and *Hippoboscidæ* taken from infected animals trypanosomes of the *T. nanum* type were found, but these only in small numbers. The *Tabanidæ*, chiefly *Tabanus socius*, in and around this district are infected with *Herpetomonas*, but there is no evidence to show that has any bearing on the trypanosome question.

At the Mission Station on the Sobat, as far as I could discover, about twenty-five per cent. of the cattle had died. Many of the cattle were suffering from Piroplasmosis (*P. mutans* and *P. bigeminum*), but the cause of death seemed to be the trypanosome. Asked as to whence the disease had come the natives gave very contradictory reports. Some said the epidemic first commenced on the Khor Filus, others that it had come with cattle from El Obeid, while some maintained it had spread from Abyssinia. At Bor I examined the blood of a large number of cattle which had just arrived from El Obeid. They were all healthy, and no trypanosomes were found. The Piroplasmata affecting the Sobat cattle are figured on Plate IV., figs. 4 and 5.

Treatment of Trypanosomiasis

A certain number of experiments were made with animals suffering from trypanosomiasis and one of the colours of benzidine (naphthalene-diamine-disulphonic acid 2736 + benzidine) which elsewhere I had found useful in treating mice artificially infected with *Trypanosoma dimorphon*. In the present instance the animals employed were mules and donkeys which had become infected naturally, presumably by the bite of *Glossina morsitans*, with the trypanosome which is probably *T. pecaudi*. The results obtained were disappointing.[1] In no case did the drug bring about the complete disappearance of the trypanosomes from the blood, though they were always reduced in number. Large quantities of drug had to be given in solution hypodermically or intra-muscularly. One gramme dissolved in the minimum quantity of distilled water was given at each injection. This quantity caused a very considerable amount of œdema around the point of injection, and in some instances abscess developed. Post mortem the animals were well coloured, in spite of which the trypanosomes had not disappeared nor was it clear that the life of the animals had been prolonged. Similar results were obtained in the case of rats artificially infected with this trypanosome. The resistance of this trypanosome to the benzidine colour in question is in favour of the view that it is distinct from *T. dimorphon*. Chromo-therapy

Treatment of Trypanosomiasis by 'Soamin'

I have been able to try the action of an arsenic preparation recently put on the market under the name of Soamin. The composition is sodium para-aminophenylarsonate, with the formula $C_6H_4.NH_2.AsO(OH)(ONa),5H_2O$. These experiments were conducted with ordinary wild rats, which were inoculated with the Sudan trypanosome (*T. pecaudi*) obtained from donkeys and mules. This strain of trypanosomes would infect rats about five days after inoculation. On the sixth day the trypanosomes were generally present in large numbers, and it was on this day that a dose of the drug was administered. If untreated the rats invariably died in about one month after inoculation. In employing the drug it was soon found that unless perfectly fresh solutions were used toxic symptoms were produced. The solution generally employed was that of 1 grain (0·064 gramme) of the drug in 5 c.c. of distilled water. The drug is readily soluble in cold distilled water, but warming facilitates solution and does not appear to produce any alteration. A rat could endure two-fifths of a grain of the drug in freshly prepared solution (2 c.c.). A solution a few days old became of a yellow or light brown tint, and of this 2 c.c. would produce toxic symptoms in rats, and frequently kill them. On one occasion 1 c.c. of such a solution killed an infected rat. Treatment with 'Soamin,' an arsonate

The drug was used on ten infected rats. The "control" untreated rats invariably died from the results of their infection. It will be seen from the details of the experiments given below that three of these rats died from the toxic effects of the drug in old solutions (Nos. 2, 3, 4). Of the remaining seven rats two died, one having been treated three times and the other twice, while five were permanently cured. One of the five suffered from relapse after the first administration of the drug, but was cured after further treatment. Recoveries amongst rats

[1] Professor Mesnil informs me that Dr. Bouffard has experimented with this colour in the treatment of animals infected with *T. pecaudi* in the French Sudan. His results are similar to those recorded here.

The drug in all cases except two (Nos. 7, 8) was injected under the skin of the back. The local effects of inoculation were practically nil. In two (Nos. 7, 8) the rats were made to drink the drug, which is quite tasteless in solution. By giving no water to the animals for twenty-four hours the required quantity of solution was at once drunk when presented to them. The results were satisfactory, for the two rats thus treated were permanently cured. It would appear from these cases that the drug is just as potent when taken by the mouth as when administered subcutaneously. One rat (No. 9) was treated with Atoxyl subcutaneously, with a permanent cure as result. The rat employed in experiment No. 1 remained cured for four months. It was then re-inoculated, and became infected as other rats. Later it died of this infection.

From the limited nature of the experiments it is impossible to pronounce very definitely on the results, or to compare the action with that of Atoxyl. If it be found that the administration by the mouth is as sure a method of giving the drug as subcutaneously, this will be a distinct advantage over Atoxyl. Colonel F. J. Lambkin, R.A.M.C., has recently experimented with Soamin in the treatment of syphilis, and has obtained very favourable results (*British Medical Journal*, Aug. 15, 1908). He has found this drug "preferable to Atoxyl" from a therapeutic point of view.

At present it is impossible to say much about the action on trypanosomes, but I am now engaged in testing it on the trypanosomes of human trypanosomiasis.

Experiments with 'Soamin'

1. Rat (wt. 65 grams): treated 6th day: large infection: $\frac{1}{5}$ grain Soamin subcutaneously. Result—cured.

   This rat was reinoculated and died of infection.
2. Rat (wt. 167 grammes): treated 6th day: large infection: $\frac{4}{5}$ grain Soamin subcutaneously (old solution). Result—died with toxic symptoms on 2nd day.
3. Rat (wt. 136 grammes): treated 10th day: large infection: $\frac{2}{5}$ grain Soamin subcutaneously (old solution). Result—died with toxic symptoms on 6th day.
4. Rat: treated 6th day: large infection: $\frac{1}{5}$ grain Soamin subcutaneously (old solution). Result—died with toxic symptoms on same day.
5. Rat: treated 7th day: large infection: $\frac{1}{5}$ grain Soamin subcutaneously. Result—relapse after 20 days.

   Second treatment $\frac{1}{5}$ grain Soamin subcutaneously. Result—cured.
6. Rat (wt. 96 grains): treated 6th day: large infection: $\frac{1}{5}$ grain Soamin subcutaneously. Result—cured.
7. Rat: treated 6th day: large infection: $\frac{1}{5}$ grain Soamin in solution by the mouth. Result—cured.
8. Rat: treated 6th day: large infection: $\frac{1}{5}$ grain Soamin in solution by the mouth. Result—cured.
9. Rat (41 grammes): treated 6th day: large infection: 12·5 milligrams Atoxyl in 1 c.c. Result—cured.
10. Rat: treated 5th day: large infection:

    $\frac{1}{5}$ grain Soamin subcutaneously—11th day relapse.
    $\frac{1}{4}$ grain Soamin subcutaneously—12th day relapse.
    $\frac{1}{4}$ grain Soamin subcutaneously—relapse and died.
11. Rat: treated 5th day: large infection:

    $\frac{1}{5}$ grain Soamin subcutaneously—21st day relapse.
    $\frac{1}{4}$ grain Soamin subcutaneously—relapse, died.

Trypanosomes

Trypanosoma numidæ, n. sp.

Host, Guinea fowl (*Numida ptilorhyncha*). Locality, White Nile

Plate XVI., figs. 21–25 and 28

Trypanosome of the Abyssinian guinea fowl

In the section devoted to the consideration of the *Leucocytozoon* of the guinea fowl it is mentioned that a trypanosome was occasionally encountered. From the figures (Plate XVI., figs. 21–25, and 28) of this trypanosome it will be seen that two types are found, a large and a small. Some trypanosomes (fig. 28) seem to hold a position intermediate between these two forms. In the small forms there is a certain resemblance to the trypanosome of the Indian pigeon described by Hanna. The non-flagellar end is very much drawn out, and the body is relatively wide. The total length of some of these small forms does not exceed 35μ.

The larger forms resemble *Trypanosoma avium* to a certain extent, but the measurements vary.

The measurements of two of these forms are as follows :—

$8{\cdot}4\mu$	$7{\cdot}0\mu$	Extremity to micronucleus.
$9{\cdot}8\mu$	$9{\cdot}8\mu$	Micronucleus to nucleus.
$4{\cdot}2\mu$	$2{\cdot}8\mu$	Length of nucleus.
$18{\cdot}2\mu$	$18{\cdot}2\mu$	Nucleus to extremity.
$5{\cdot}6\mu$	$7{\cdot}0\mu$	Flagellum.
$5{\cdot}6\mu$	$2{\cdot}8\mu$	Width of body at nucleus.

For this trypanosome, which does not correspond to any known species, I suggest the name *Trypanosoma numidæ*, from its host, *Numida ptilorhyncha*.

Trypanosoma mabuiæ, n. sp.

Host, *Mabuia quinquetæniata*. Plate XII., figs. 13, 15, 16, and Plate XV., figs. 7, 9, 11

A lizard trypanosome

In the lizards of Wau which harboured the two parasites described under the names of *Hæmogregarina gracilis* and *Plasmodium mabuiæ* there occurred also a trypanosome which was to be found in two very definite forms. One of these forms resembles *Trypanosoma rotatorium* of frogs and the other *Trypanosoma inopinatum* of the same amphibian. The broad form is shown in Plate XII., fig. 13, and in drawings from life in Plate XV., figs. 7, 9, 11. The figures on Plate XV. are from a single trypanosome in varying positions. It will be seen that the body of the trypanosome is a leaflike portion of protoplasm which is doubled over along its long axis. One side of the body is undulatory in the living condition and represents the undulating membrane. Along the border of this membrane runs the continuation of the flagellum as in other trypanosomes. In films stained by Giemsa stain the body of the trypanosome stains a deep blue and is filled with dark staining granules. There is a free flagellum continued along the membrane towards the opposite end of the body. The nucleus and micronucleus are difficult to distinguish. The length of the large forms is roughly $30–40\mu$ and the breadth $8{\cdot}5\mu$, but owing to the shape of the body measurements are difficult to make.

Two forms in the blood

The small forms of this trypanosome are shown in Plate XII., figs. 15 and 16. They measure 20 to 25μ in length and about 2 to $2{\cdot}5\mu$ in breadth. There is a free flagellum, and the non-flagellar end is pointed. The flagellum arises from a micronucleus situated near to the pointed extremity. The nucleus is near the micronucleus. The undulating membrane is fairly straight.

The exact relations of the two forms of trypanosome met with in these lizards have not been determined. It is possible they represent distinct species, or they may be different stages of one species; intermediate forms were not seen. The large trypanosome resembles *Trypanosoma boueti* described by Martin from *Mabuia raddonii.* In absence of evidence to the contrary it will be convenient to group both forms together as two types of one trypanosome, for which I propose the name *Trypanosoma mabuiæ.*

Trypanosoma varani, n. sp.

Host, *Varanus niloticus.* *Varanus,* sp. Locality, Taufikia, White Nile

Plate XIII., figs. 11–13

This trypanosome was encountered with a hæmogregarine in the blood of the Nile monitor (*Varanus niloticus*), and from the same locality in another species of *Varanus* which is to be found inland away from the river banks.

Trypanosome of the Monitor lizard

In the fresh blood this trypanosome resembles *Trypanosoma rotatorium* of frogs. The general shape of the body is that of the letter U. The undulating membrane runs round the convexity of the bend. The movements are not very rapid, and consist mostly of a rotation with little progression across the microscopic field.

The appearance in stained films is shown in Plate XIII., figs. 11–13. The body is broad, at its widest part measuring from 6–8μ. The total length is from 35–40μ. The non-flagellar end is long and pointed and continued for about 15μ beyond the micronucleus. The nucleus is situated at the bend of the looped body. The undulating membrane is broad and wavy, and its margin is continued as a free flagellum for about 5–6μ. The protoplasm stains deeply, showing various granules and vacuoles. Both in the living state and in the stained films the looped condition of the body is maintained, so this appears to be the permanent shape of the parasite. I propose the name *Trypanosoma varani* for this parasite.

Trypanosoma chamæleonis, n. sp.

Host, *Chamæleon gracilis.* Locality, Wau, Bahr-El-Ghazal Province

Plate XIII., fig. 17

Trypanosome in a chameleon

This trypanosome, which resembles the foregoing in many respects, differs in several points. The movements in the fresh blood are similar, but the looping of the body is not so well marked. In the stained films only one good specimen was found, and this was too deeply stained. It is reproduced in Plate XIII., fig. 17. It will be seen that the body is straighter than in *Trypanosoma varani,* and the non-flagellar end is less pointed. The position of the nucleus and micronucleus was obscured by the dense staining. The length of the body is about 40μ. For this species I propose the name *Trypanosoma chamæleonis.*

Trypanosoma najæ, n. sp.

Host, *Naja nigricollis.* Locality, River Sobat

Plate XV., figs. 1 and 2

Trypanosome of the black-necked spitting snake

This trypanosome was only met with in the fresh blood. A prolonged search in stained films failed to reveal a single example. As seen in the wet films the parasite is shown at Plate XV., figs. 1 and 2. It will be noticed that the body is looped in a characteristic spiral manner. This form is retained in all the movements of the parasite. In moving, the body rotates around the axis of the spiral. The non-flagellar end extends some distance

PLATE X

C. M. Wenyon

Scale = 10 μ
1–15

Scale = 10 μ
16–19

1–8. *Babesia avicularis*, n. sp.

1. Budding parasite
2. Pyriform parasites
3, 4. Amœboid forms
5, 6, 7. Ring forms of parasite
8. Amœboid form
9. *Trypanosoma avicularis*, n. sp.
10–14. Trypanosomes from blood of camels returning from the Bahr-El-Ghazal Province. Probably *Trypanosoma pecaudi*
15. Multiplication form of *T. lewisi* in blood of rat artificially infected. Shows very well the chromatic and achromatic part of the micronucleus, which appears to be enveloped by a delicate membrane, from the surface of which springs the flagellum
16. *Trypanosoma megadermæ*, n. sp., from the bat *Megaderma frons*
17–19. Various forms of *Trypanosoma acomys*, n. sp., of the spiny mouse
17. Prevailing type of trypanosome
18. Much altered form seen on several occasions
19. Large form only occasionally met with

beyond the commencement of the undulating membrane, which is well defined. There is a free flagellum. As far as could be judged by measurements on the living trypanosome the total length of the body was about 50μ. In the blood of the same snake there occurred with the trypanosome a hæmogregarine and a hæmocystidium, which have been described at another part of the report. For this trypanosome I propose the name *Trypanosoma najæ*, from its host, *Naja nigricollis*.

Trypanosoma avicularis, n. sp.

Host, *Avicularis zebræ*. Locality, Bor, River Jebel

Plate X., fig. 9

This trypanosome occurred in large numbers in the same zebra mouse in which the parasite described under the name of *Babesia avicularis* was discovered. In many respects this trypanosome resembles *Trypanosoma duttoni*, but there are differences in the measurements of the two. The measurements of one of these trypanosomes are as follows: Non-flagellar end to micronucleus $4{\cdot}2\mu$, micronucleus to nucleus $7{\cdot}0\mu$, length of nucleus $1{\cdot}5\mu$, nucleus to flagellar end $7{\cdot}0\mu$, flagellum $4{\cdot}2\mu$; width at nucleus $1{\cdot}5\mu$. Such a trypanosome is shown in Plate X., fig. 9. The non-flagellar end is fairly long, the micronucleus is large, and undulating membrane straight. These trypanosomes were only seen in the stained films, and no inoculation experiments were made.

Trypanosome of the striped mouse

Trypanosoma acomys, n. sp.

Host, *Acomys*, sp. (Spiny Mouse). Locality, Taufikia, White Nile

Plate X., figs. 17–19

This trypanosome is found in several forms. One form, which is the common type, resembles the trypanosome just described as *T. avicularis* in size, but differs in the arrangement of the nucleus and micronucleus (fig. 17). The flagellum is longer. In addition to this type, which measures about 25μ in total length, there are some much larger forms measuring up to 50μ in length (fig. 19). These have the non-flagellar end much elongated beyond the micronucleus, while the nucleus is nearer the flagellar than the non-flagellar end of the body. Such trypanosomes are probably multiplication forms. Irregular forms are also met with (fig. 18). In the irregularity of structure this trypanosome reminds one of *T. lewisi*, but it evidently differs from this. It resembles *T. duttoni*, but differs from it in the presence of the very large forms and in other features.

Trypanosome of the spiny mouse

Trypanosoma megadermæ, n. sp.

Host, *Megaderma frons*. Locality, Bor, Jebel River

Plate X., fig. 16

A trypanosome which appears to differ from any hitherto described species was encountered in a bat at Bor. This trypanosome is peculiar on account of its large size, 40μ, and its much elongated non-flagellar end, which is drawn out to a fine whip-like process. The movements in the fresh blood are not as active as those of *T. lewisi*, though sufficient to enable the parasite to move across the field of the microscope. The measurements of a typical example are as follows: non-flagellar end to micronucleus $11{\cdot}2\mu$, micronucleus to nucleus $7{\cdot}0\mu$, length of nucleus $2{\cdot}8\mu$, nucleus to flagellar end $11{\cdot}2\mu$, flagellum $8{\cdot}4\mu$; width at nucleus 3–$3{\cdot}5\mu$. This trypanosome was found in half the bats examined. The infection was never very large.

Trypanosome in a bat

Trypanosoma lewisi

Plate X., fig. 15

T. lewisi in rats

Trypanosoma lewisi was met with in rats from various parts of the southern Sudan. These rats were all of the genus *Mus*. In one case inoculation of a small mouse (? young rat) from another rat infected with the trypanosomes of the donkey produced in three days an enormous infection of *T. lewisi*. In this animal all the reproductive forms characteristic of this trypanosome were found. In Plate X., fig. 15, is depicted a form which is interesting, as it shows very clearly the connection of the flagellum with micronucleus. Each micronucleus consists of two parts, a chromatic and an achromatic part. It appears as if the micronucleus is spherical, and the half of this sphere nearest the nucleus is chromatic, while the half directed away from it is achromatic. The whole micronucleus seems to be limited by a delicate membrane, which stains as the chromatic portion. The flagellum springs from the outer surface of the achromatic hemisphere and is directly connected with the membrane limiting the micronucleus. The flagellum terminates at the surface of the micronucleus and cannot be traced into its interior. It would thus appear that the flagellum is in some way related to this limiting membrane. Possibly the same process which causes the formation of the membrane, if carried on actively at one spot, would result in a flagellum. In fig. 15 it will be noticed that connected with each micronucleus are two flagellum-like processes. One of these terminates at the surface of the body; the other is prolonged as a free flagellum. Whether the shorter one is divided off from the longer or represents a new flagellum growing out from the micronucleus cannot be stated. Laveran and Mesnil and MacNeal have described the connection of the flagellum of *T. lewisi* with an achromatic structure which lies close to the micronucleus. In the present instance the achromatic structure is part of the micronucleus and reminds one of the similar body seen in cultural forms of the parasite of kala-azar.

Trypanosomes in Fish

Trypanosomes of Nile fish

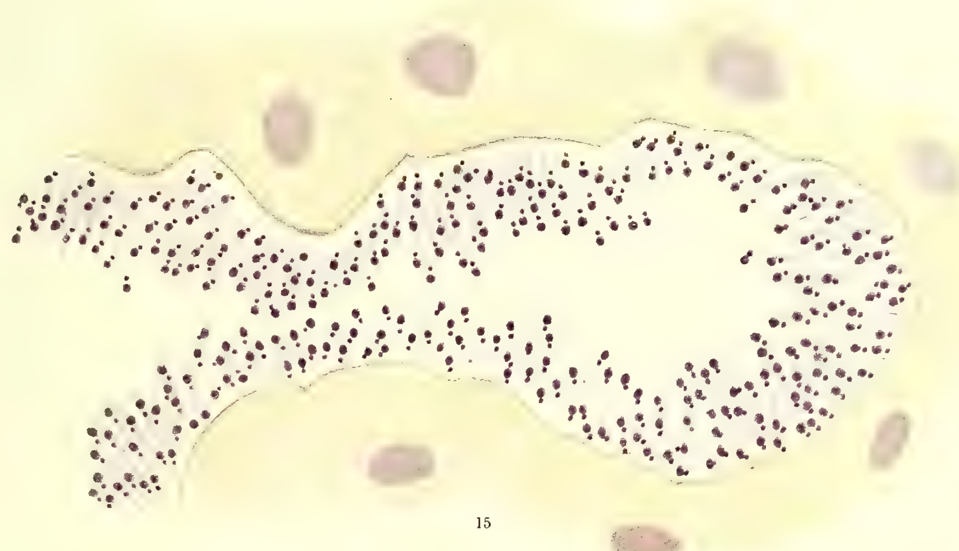
Trypanosomes were met with in several fish from the Nile. In the Farfou fish (*Tilapia zillii*) they were constantly present. The measurements of one of these trypanosomes was as follows: Non-flagellar end to micronucleus $1 \cdot 5\mu$, micronucleus to nucleus 18μ, length of nucleus 3μ, nucleus to flagellar end 21μ, flagellum 14μ, width of body at nucleus 4μ.

Trypanosomes were found in the Bagara fish, Gargur fish, Noke fish as described by Sheffield Neave. I failed to find trypanosomes in *Polypterus*. There are several species of Gargur fish (*Hynodontis*) in the Nile and each is infected with trypanosomes. I found trypanosomes in the Garmoot fish (*Clarias anguillaris*) rarely, though this is a mud-feeding fish which abounds in the Nile, and especially in Lake Ambadi on the Bahr-El-Ghazal. Trypanosomes were also seen in *Chrysichthys auratii*, and finally in the curious fish *Ophiocephalus obscurus* a trypanosome and a hæmogregarine were found (Fig. 40, A and B). This trypanosome measures 40μ in length and 3–4μ in breadth. The flagellum is about 4μ long; there is a large micronucleus situated at the extreme end of the body, while the nucleus is behind the middle point of the body.

Fig. 40.—Trypanosome and Hæmogregarine of *Ophiocephalus obscurus*

PLATE XI

C. M. Wenyon



R. D. Muir

× 1000 *diam.*

1–10, 15. *Herpetomonas* OF *Tabanus socius*

1. Large globular form with free flagellum
2. Small free *Herpetomonas*
3. Resting form with two nuclei and dividing micronucleus
4. Rosette with one free form with long flagellum
5. Rosette with larger forms than in 4
6. Free form with the thin membrane-like lateral expansion of the body
7. Very small rosette
8, 9. Two free forms
10. Large rosette of elongated forms. Many of these show the same lateral membrane that was seen in the parasite at 6
15. Section of gut of *Tabanus socius*. Fixed in Flemming's solution, stained with Iron Hæmatoxylin and Eosin. Shows the arrangement over the surface of the gut of the *Herpetomonas*

11–14. Various forms of the *Herpetomonas* from *Myzomyia nili*

Trypanosomes in Toads. Plate III., fig. 2

In the common toad of the Sudan (*Bufo regularis*) trypanosomes, hæmogregarines, and filariæ were common. The trypanosomes were of several types, which may all be developmental stages of one trypanosome.

Three forms of trypanosome in the common Sudan toad

1. Leaflike trypanosomes resembling *T. rotatorium.*
2. Large trypanosomes up to 70μ in length and about 5–6μ wide.
3. Very narrow trypanosomes about 30μ long and 1·5μ wide. The nucleus and micronucleus are close together at the junction of the anterior and middle thirds of the body. There is a free flagellum. The presence of a trypanosome and hæmogregarine in this toad has been noted by Dutton, Todd and Tobey.

Flagellates in Biting Flies

Tabanidæ

Plate XI., figs. 1–10, 15

Flagellates in biting flies

As already mentioned, Dr. Balfour and I found in the intestine of *Tabanus socius*, the Seroot fly, a flagellate of the genus *Herpetomonas*. On the journey up to Taufikia from Khartoum these flies came into the floating laboratory in large numbers, attacking both men and animals. As this fly is most persistent in its attempts to suck blood, we thought it of interest to make dissections of the gut. As a result of these enquiries we found that, roughly, about one fly in every fifty harboured the above-named flagellates in its gut. At Taufikia, on the Sobat, and at other places in the Sudan, I continued the dissection of these flies and also other species. At Nasser, where *Tabanus socius* occurred in abundance, I found a much larger percentage of flies infected. Here it was not unusual to meet with the *Herpetomonas* in every third fly examined. At Nasser, four other species of *Tabanus* were examined. These were *T. fasciatus, T. biguttatus, T. africanus*, and *T. par*, but only in two of the last-named species were *Herpetomonas* found. Later in the year, in the Bahr-El-Ghazal Province, *Herpetomonas* was discovered in other species, viz. *T. ditæniatus, T. africanus, T. fasciatus, T. gratus, T. virgatus*, so that altogether seven species of *Tabanus* were found to be infected with this flagellate. In all these flies, as far as could be determined by examination of the fresh and stained specimens, the *Herpetomonas* belonged to one species. In the majority of flies the flagellate was in the resting condition and attached to the lining of the gut. It was never found as far forwards as the stomach, and mostly in the gut behind the Malpighian tubes. In only a few instances were free motile forms seen, and these in the portion of gut into which the Malpighian tubes opened or just posterior to this part. When only resting forms were present, as was generally the case, it was found that the nearer the Malpighian tubes the more did these forms resemble the free forms, and conversely the nearer the anus the more did they approach to the stage of encystment. In the hindermost portion of the gut, small bodies of oval outline and with two chromatin dots at one end, one large and the other small, were frequently seen. These are undoubtedly the encysted forms of *Herpetomonas*, which are destined to escape to the exterior. Such cysts have been described by Prowazek, Minchin, and others. They bear some resemblance to the encysted forms of *Hexamitus* from the gut of mice (Wenyon).

Herpetomonas in Seroot flies

A section of the gut in the neighbourhood of the Malpighian tubes is figured on Plate XI., fig. 15. It will be seen that the whole surface of the gut is lined with *Herpetomonas* attached by their flagellar ends. Various forms of these parasites, as seen in films stained with Giemsa stain, are shown in Plate XI., figs. 1–10. It will be evident from the figures, which are all drawn to one scale, that there is a great variation in the size of both the free and resting forms.

Typical free forms are shown at figs. 4, 6, 8, 9. The body is elongated and blunt at either end. The micronucleus is not far from the macronucleus, and there is a free flagellum. Never were true trypanosome forms seen nor forms with the micronucleus on the non-flagellar side of the macronucleus. In some cases (figs. 2, 6, 10) one side of the parasite was evidently thinner than the other, and this had the appearance of an undulating membrane, with this difference, that the flagellum did not run along its margin, as it does in true trypanosomes. This membranous lateral extension of the body is especially well shown in fig. 6 and in some of the forms in fig. 10. It will be noticed that this extends the whole length of the parasite; and if, for instance, in the form depicted at fig. 6, the flagellum were bent backwards and attached to this structure, the appearance of a true trypanosome would be produced. Whether this structure is truly homologous with the membrane of a trypanosome or not cannot be stated, but the appearance gives some support to this view. In the resting forms the body becomes contracted to approach the spherical and the flagellum shortened. Multiplication in this stage goes on producing the rosettes which have been described for other *Herpetomonas*. The individuals of these rosettes vary much in size (Plate XI., figs. 4, 5, 7, 10). Each rosette appears to be the product of one *Herpetomonas* which has attached itself to the gut wall. As the rosettes increase in size, adjacent ones run into one another, till, finally, the whole gut wall is covered with a layer of these flagellates and the condition shown in Plate XI., fig. 15, is produced.

Rosettes of *Herpetomonas*

The significance of these *Herpetomonas*, from the point of view of trypanosomiasis, has been discussed above. Several attempts were made to infect rats by inoculating them with a citrate emulsion of infected gut of *Tabanus socius*, but with no result.

Myzomyia Nili

Plate XI., figs. 11–14

Herpetomonas in an Anopheline mosquito

Though some hundreds of mosquitoes of different kinds were dissected at one place and another, in only one species were flagellates found. This was in one *Myzomyia nili* at Nasser, on the Sobat, in which a species of *Herpetomonas* was discovered. These differed from the forms found in the *Tabanidæ* at the same place in that the non-flagellar end of the body was drawn out into a fine pointed extremity. In some there was the appearance of a short membrane (fig. 13). Resting forms occurred as well as free forms, and these were either pear-shaped or spherical. None of the forms met with showed the true trypanosome structure.

Glossina Palpalis

At Wau and on the Sueh river, about ten miles above Wau, twelve *Glossina palpalis* were dissected, but no flagellates were present in the guts of these. The number of flies dissected was too small to allow of any conclusions being drawn.

On several occasions *Hippoboscidæ* and *Stomoxys*, taken from domestic animals infected with trypanosomes, revealed these parasites in their intestines, but there was nothing to show that their presence there was anything more than accidental.

Plasmodia

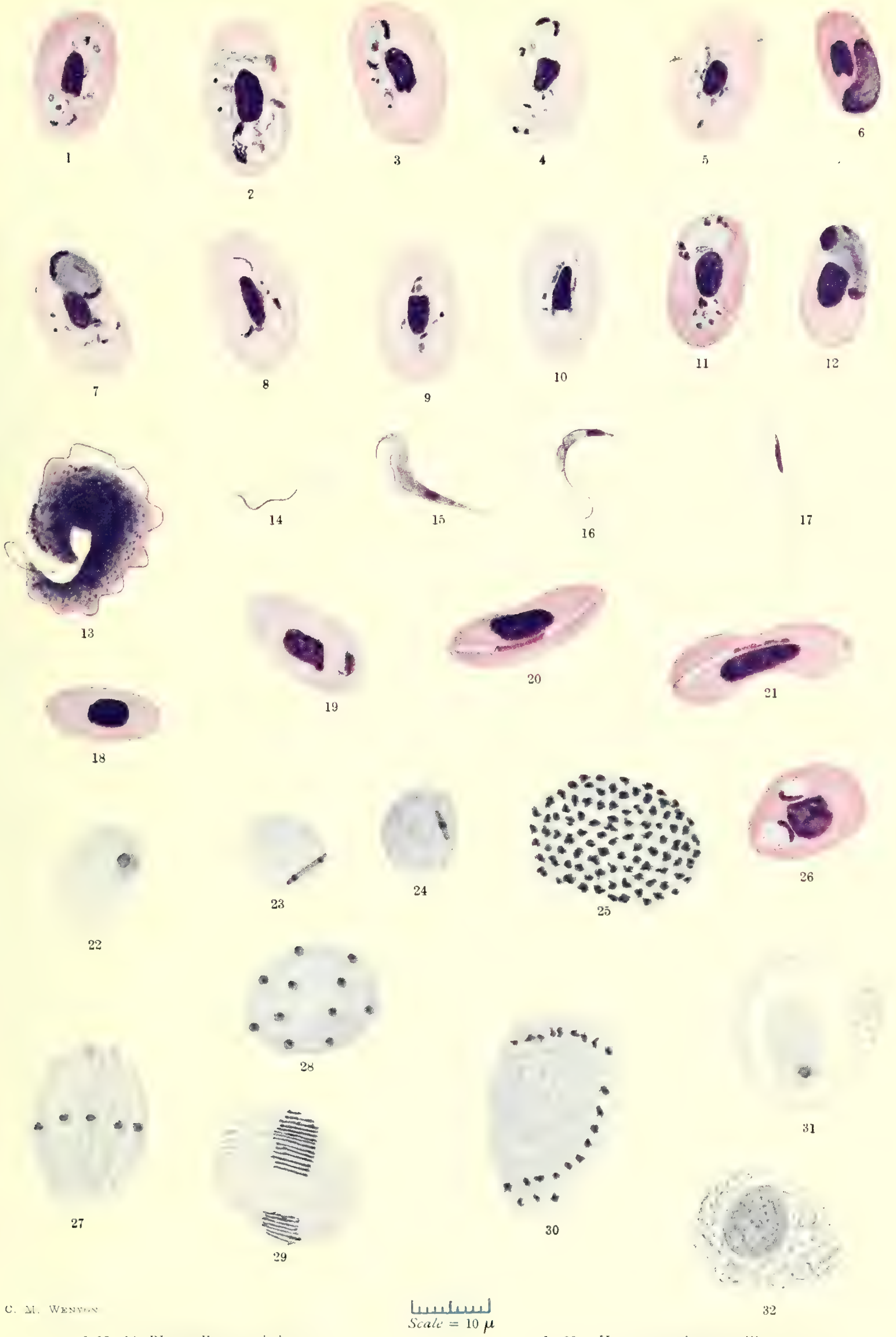
Plasmodia

Plasmodium mabuiæ, n. sp.

Host, *Mabuia quinquetæniata*. Locality, Wau, Bahr-El-Ghazal Province

Plate XII., figs. 1–12, 14

This parasite was discovered in the red corpuscles of a lizard (*Mabuia quinquetæniata*) which was very common in and around Wau, where it was seen either in the grass or on the



1–12, 14 *Plasmodium mabuiæ*, n. sp.

1–5. Various amœboid forms showing relation to nucleus of host-cell. Male gametocyte in 2
6. Female gametocyte
7. Female gametocyte and amœboid form in one cell
8–10. Amœboid forms lying round nucleus
11. Schizonts
12. Female gametocyte
14. Microgamete showing either flagellum or membrane at thicker end

13, 15, 16. *Trypanosoma mabuiæ*, n. sp.

13. Large form of trypanosome
15, 16. Two of small trypanosomes

18–32. *Hæmogregarina gracilis*, n. sp.

18. Uninfected red cell of host
19. Small round form of hæmogregarine
20, 21. Hæmogregarines encysted in red cells
22–24. Young schizonts in liver
25. Large multinuclear schizont which will give rise to narrow hæmogregarines (micromerozoites)
26. Two round forms of hæmogregarine in one cell
27. Macromerozoites from liver
28. Schizont which will give rise to macromerozoites
29. Micromerozoites from liver
30. Developing micromerozoites
31. Young schizont in liver cell
32. Cyst containing tangled mass of micromerozoites and residual body

22–25 and 27–32 are from sections or smear preparations of liver stained by Hæmatoxylin

17. Hæmogregarine free in the blood plasma

red stone which abounds in this district. The parasite in question occurred in the blood with two other parasites, one a hæmogregarine and the other a trypanosome. The three parasites were quite independent of one another, there being nothing to indicate that they represented different stages of any one parasite.

Plasmodium in a lizard

The parasite to be described here resembles in many respects the *Plasmodium* (*Proteosoma*) of birds. It is a pigmented intra-corpuscular parasite of the red cell, and is found in three distinct forms—viz., male and female gametocytes and schizonts.

The youngest forms are found in close association with the nucleus of the red cell, and this position is maintained during the trophic stage. While in contact with the nucleus the parasite is very amœboid, and is seen as numerous pseudopodia extending from the nucleus into the body of the red cell (Plate XII., figs. 1, 5, 7–10). In many of these stages it appears as if the parasite is intra-nuclear and is extending pseudopodia out of the nucleus, but it may be that the nucleus is merely surrounded by the parasite, which occupies this position for some purpose of nutrition. In the case of the *Plasmodium* of birds a similar position in contact with the nucleus is often observed. At this stage in films stained by Giemsa stain, the parasite is seen surrounding the nucleus. The protoplasm stains a faint blue, and there may be one or more chromatin granules arranged at varying places in the body of the parasite. Pigment is present in the shape of fine granules, which are frequently clustered together into several groups at different spots. Such forms as are represented in Plate XII., figs. 5, 9, 10, may be a group of several distinct parasites or one amœboid parasite surrounding the nucleus. The presence of the parasites in contact with the nucleus has little effect on this structure, apart from a slight irregularity in its contour. In staining reaction there is little difference from the uninfected red cells. In the fresh blood the forms associated with the nucleus show very slight amœboid movements. In no case was so great a movement as the total withdrawal of a single pseudopodium observed.

Morphology of the parasite

As has been mentioned above, some of these forms have several chromatin granules. Other forms are met with which are spherical and lying away from the nucleus. Such a form is represented in Plate XII., fig. 11. It has six chromatin dots, and the body of the parasite appears to be undergoing segmentation into six merozoites. These forms are evidently schizonts. Apart from these amœboid forms, which appear to become ultimately schizonts, are the gametocytes, male and female. The male gametocytes are pale staining bodies (figs. 2, 11) of oval contour. They occupy one end of the red cell without altering the shape of the cell or displacing its nucleus. Granules of fine pigment are scattered through the body of the parasite, or, more commonly, arranged in clusters at the periphery. The nucleus is a group of chromatin granules at the centre of the gametocyte. The size of the gametocyte may be $8{\cdot}5\mu$ by $5{\cdot}5\mu$. Usually it is a little smaller than this. The female gametocyte differs little from the male except in the density of its protoplasm, which consequently stains a deeper blue (figs. 6, 7, 12). In gametocytes which have been deeply stained, dark red masses of a substance resembling the material of the host-cell nucleus appear on the surface of the parasites. These dark red staining areas occur at the spot where the pigment grains are clustered into heaps which are quite obscured by the presence of this substance. It is only present in deep staining, and what its nature is cannot be stated unless it be merely a deposit of red stain around the grains of pigment (Plate XII., figs. 3, 6, 7, 12). It must not be confused with the several chromatin clusters seen in the schizonts. In the fresh blood the gametocytes are very sluggish and show little movement. In vain was search made for microgametic formation in the fresh blood, but in some of the stained films, forms which were undoubtedly microgametes were encountered. A microgamete is represented in fig. 14. In the same film, spherical extra-corpuscular male and female gametocytes were met with, so that, as these films were made from a lizard some two hours after it was killed, it is possible that microgametes are formed from the male gametocyte in much the same way as in the case of the *Plasmodium* of birds. The microgametes (fig. 14) are flagellum-like portions of protoplasm which are slightly tapering, one end being a little thicker than the other. They are about 16–20μ in length. At the thicker end is a structure which is either a membrane or a flagellum. It is constantly present as a line which leaves the thickest end of the body at an acute angle, passes towards the thinner end of the body for a short distance ($\frac{1}{6}$ of length of body), and then joins the body again. It might be interpreted as the margin of an undulating membrane which has its widest part at the thicker end of the body. After leaving the end of the body it always curves in again to join the body, and this is more in accord with its interpretation as a membrane. After joining the body again it cannot be traced any further. Chromatin is distributed irregularly along the body of the microgametes as in other *Plasmodia*. In the case of large infections about one corpuscle in every field (obj. $\frac{1}{12}$ oc. 4, Zeiss) is infected with this parasite.

This parasite was present in about half the lizards examined. It always occurred with the hæmogregarine (Plate XII., figs. 20, 21), and sometimes with the trypanosome (Plate XII., figs. 13, 15, 16). Double infection of the corpuscles with hæmogregarines and this parasite was common. For this parasite, which evidently has affinities with *Plasmodium* of birds, I suggest the name *Plasmodium mabuiæ*.

Hæmoproteus

HÆMOPROTEUS

Hæmoproteus agamæ, n. sp.

Host, *Agama colonorum*. Locality, Wau, Bahr-El-Ghazal Province

Plate XIII., figs. 1–10; Plate XV., figs. 12, 14

This parasite was discovered in the blood of a lizard (*Agama colonorum*) at Wau, in the Bahr-El-Ghazal Province. It was found in the blood of several lizards examined at Wau, and again in one lizard taken at Dem Beshir Wood Station, lower down the Jur River. The infection was never a very large one.

Hæmoproteus in a lizard

Appearances in the fresh blood

In the fresh blood could be distinguished several types of parasite. There are the small immature forms of various shapes, which appear as white transparent areas in the corpuscle, and having from one to more brown pigment grains. The grains of pigment increase in number with the size of the parasite. There is a general tendency towards an elongation of the body of the parasite, as occurs in *Halteridium* of birds. A slow change in the shape of the parasite takes place, and there is a corresponding movement in the pigment granules, which slowly alter their position. Definite pseudopodia do not appear to be formed. The smallest forms observed are oval or flame-shaped, and have no pigment granules. The largest types are of two varieties—male and female gametocytes. The male gametocyte is an elongated or sausage-shaped body, occupying usually one end of the cell and extending round one side of the nucleus towards the other end of the corpuscle. Its protoplasm is white and very feebly refractile. It strikes one as being of a very liquid nature, and this appearance is intensified by the rapid streaming of the coarse pigment grains. The female gametocytes are early distinguished from the preceding. They are more definitely sausage-shaped, though one end has a tendency to be more pointed than the other. The protoplasm of the female gametocyte is highly refractile, and this gives it a greyish colour, which appears in sharp contrast to the white colour of the male forms. The pigment granules in the female gametocyte are more numerous and finer than those of the male. In the fresh blood no forms could be distinguished as definite schizonts.

PLATE XIII

1–10. *Hæmoproteus agamæ*, n. sp.

1. Male gametocyte
2. Young male gametocyte
3. Schizont
4. Female gametocyte
5. Male gametocyte preparing for microgamete formation
6. Young female gametocyte
7. Female gametocyte
8. Schizont
9, 10. Young forms

11–13. *Trypanosoma varani*, n. sp.

17. *Trypanosoma chamæleonis*, n. sp.

14–16. HALTERIDIUM OF JABIRA CRANE (*Epippiorhynchus senegalensis*)

14. Male gametocyte surrounding nucleus
15. Male gametocyte displacing nucleus
16. Female gametocyte surrounding nucleus

18–20. Curious forms of *Halteridium* from blood of *Hypanthornis tæniopterus* showing flagellum-like prolongation of one end

21, 22. Type of *Halteridium* commonly met with in birds in the Sudan

Fresh blood preparations observed for several hours showed no change other than the slow movements mentioned above. Eventually these ceased, and the parasites died. Thinking that as these were parasites of cold-blooded animals, the conditions of microgamete formation might differ from the process as it occurs in the parasites of birds, blood was mixed with a solution of sodium citrate acidified with citric acid. This caused the male gametocytes to become very active. The granules streamed rapidly about the cell, and the whole parasite contracted to a spherical body. At the same time a kind of revolving movement of the whole parasite commenced, and this, with slight changes in shape, eventually ended in a rupture of the corpuscle and the escape of the parasite to the exterior. The granules of pigment now moved more rapidly than before. The parasite remained attached to the broken-down host-cell, which became paler owing to the solution of its hæmoglobin in the plasma. After the "dance" of the pigment granules had gone on for a short time, microgametes were formed to the number of five. These remained attached to the body of the parasite and lashed about for some time, finally freeing themselves and swimming away out of view. The whole of this process closely resembles the formation of the microgametes in *Halteridium* and other similar parasites. In the case of the female gametocyte there was a change in shape, the parasite becoming more spherical. On no occasion did I see the gametocyte leave the host-cell. Fertilisation was not observed, but in a number of instances two small bodies were seen in the corpuscle near the parasite. (Plate XV., fig. 12.) These may have something to do with the maturation of the female gametocyte. The process of microgamete formation is illustrated in Plate XV., fig. 14.

Gametocytes

Examination of stained films reveals little more than has been described from the fresh blood. The different forms described above are again encountered. The nucleus of the parasite varies from a single grain of chromatin in the smallest forms to a group of chromatin grains in the larger. In the male gametocyte (Plate XIII., figs. 1, 5) the chromatin is in the form of fine granules distributed about the middle of the cell. In the female gametocyte (Plate XIII., figs. 4, 7) there is a collection of granules more compact than in the male cell, and one granule is frequently seen larger than the rest, just as occurs in the female gametocytes of *Halteridium*. It will be seen from the figures that the female gametocytes stain a deep blue colour, while the male gametocytes stain a pale blue or lilac. Fig. 5 is a male gametocyte contracted to a spherical body prior to escape from the host-cell. The young forms are shown at figs. 9, 10. These are flame-shaped, and in the parasite depicted at fig. 10 is seen a vacuole which is frequently met with in these young stages. The dimension of the full-grown gametocyte, male and female, is generally 14μ in length by 4μ in breadth. The red cells of the host vary from 13 to 18μ in length.

Appearances in the stained blood

Little change is produced in the red cells by the parasite. The nucleus is slightly displaced, and the corpuscle remains unaltered in shape. The variation in the measurements of the uninfected red cells covers any alteration in size of the corpuscle which the parasite may produce. In this and in other features the parasite shows marked similarity to *Halteridium* of birds.

A prolonged search through the films revealed a few forms which may be interpreted as schizonts. Two such forms are illustrated in Plate XIII., figs. 3, 8. They have the chromatin scattered, and the pigment is more or less concentrated at the centre. They look like schizonts preparing for schizogony, but in no instance was there seen a parasite which had broken up into merozoites. Since young forms are frequently encountered in the blood some form of multiplication must be taking place. The only forms met with, besides the young and full-grown gametocytes, are these bodies with several chromatin granules. It is possible they represent male gametocytes preparing for microgamete formation, but the size of the parasite (fig. 3) is against this view. Unless these are schizonts, we must assume that some form of

Schizonts

multiplication takes place in the internal organs, perhaps after the manner of the asexual multiplication of *Halteridium* recently described by Aragao. This is the first time, as far as I am aware, that such a parasite has been noted from a cold-blooded host. The parasite differs markedly from the *Hæmocystidium* described by Simond in the blood of the fresh-water tortoise in India and by Castellani and Willey in *Hemidactylus leschenaultii*, from the same country. It differs also from the similar parasite described by Laveran from *Testudo pardalis* of South Africa. The affinities of this parasite are evidently with those of *Halteridium*, from which it differs, however, in the shape of the gametocytes and, perhaps, in the fineness of the pigment grains. This latter feature, however, is very variable in different species of *Halteridium*. I suggest for this parasite the name *Hæmoproteus agamæ*, from its host *Agama colonorum*.

Halteridium

HALTERIDIUM

Plate XIII., figs. 14–16, 18–22

In various species of birds

Halteridium (*Hæmoproteus danilewski*) was met with in a number of birds. The parasites differ according to the host, and probably do not all belong to one species. In the Jabira crane (*Epippiorhynchus senegalensis*) a large variety was encountered. This is figured in Plate XIII., figs. 14–16. The gametocytes fill the cell, either by completely surrounding the nucleus (fig. 16), or by displacing the nucleus to the side of the corpuscle (fig. 15). The female gametocyte is shown in fig. 16, the male in figs. 14, 15. Flagellation occurred very readily. The male gametocytes have coarse pigment, while the female have fine pigment. It will be readily seen that this species differs from the type figured at Plate XIII., figs. 21, 22, which is the form usually met with in birds. This species, or species not readily separated from one another, occurs in the common sparrow of the Sudan (*Hypanthornis tæniopterus*), in the guinea fowl (*Numida ptilorhyncha*), in the northern crowned crane (*Balearica ceciliæ*), in the white-faced owl, the Marabou stork, and other birds. A curious appearance (Plate XIII., figs. 18–20) was noted in the case of the *Halteridium* of a sparrow. One end of the parasite was drawn out into a fine process which reminded one of a flagellum. This was, however, more a fine pseudopodium than a flagellum, as the staining characteristic of a flagellum was not present. Possibly it is produced in the process of development which takes place when the blood is removed from the host, and is brought about by the contraction of the gametocyte to a spherical form. It was only found in the case of the female gametocytes. These resemble some of the figures given by Schaudinn of the development of the trypanosome into the *Halteridium*, but there is nothing to show that there is anything more than a slight superficial resemblance between such forms and true trypanosomes.

Hæmocystidium

HÆMOCYSTIDIUM

Hæmocystidium najæ, n. sp.

Hosts, *Naja hajæ*, *Naja nigricollis*. Locality, River Sobat

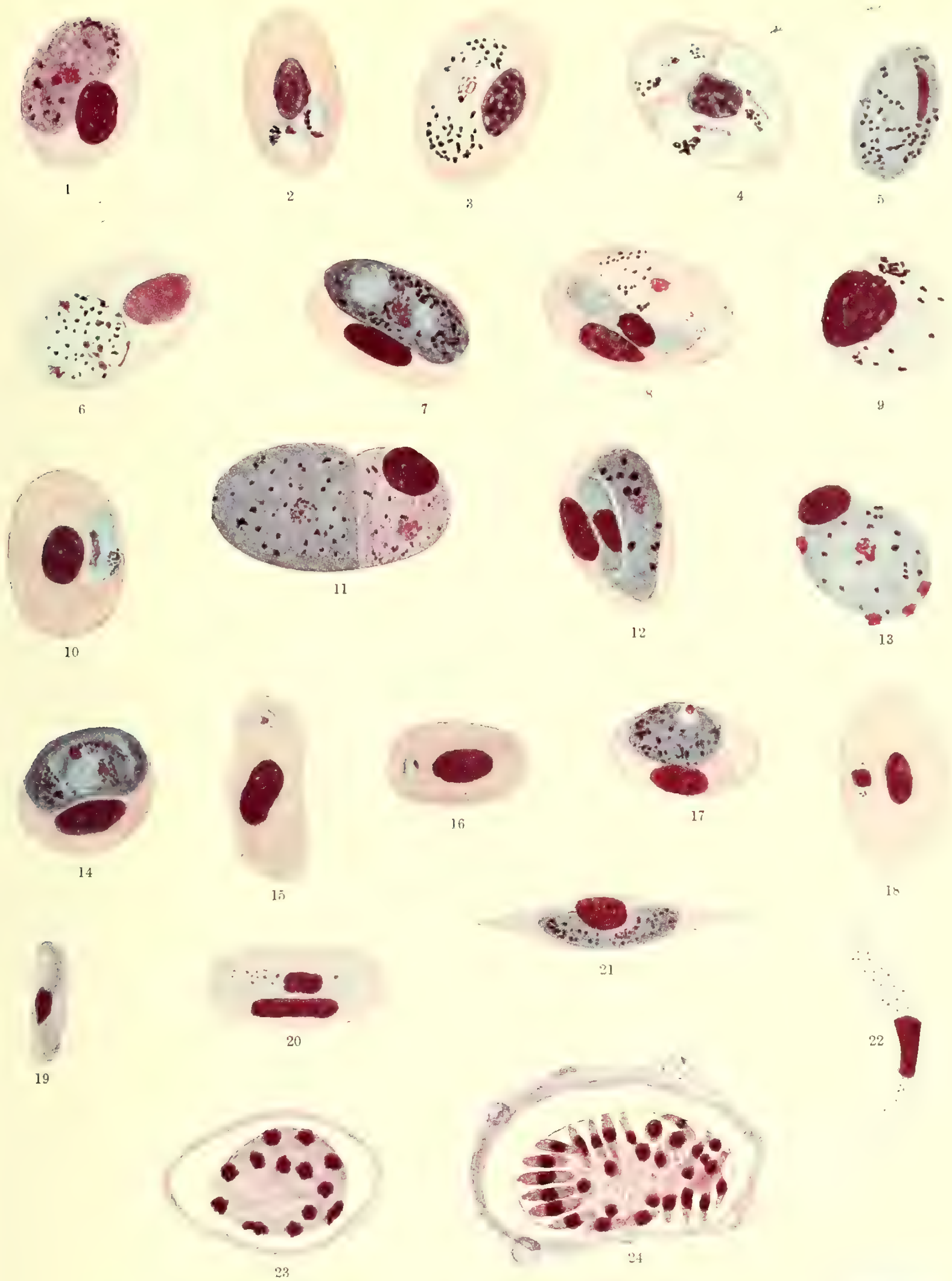
Plate XIV., figs. 1–17, 21; Plate XV., figs. 4, 5, 6

In the spitting snakes of the Sobat

This parasite was encountered in the blood of two cobras taken on the Sobat. One snake, *Naja hajæ*, was captured at the American Mission Station at Deleib Hill, the other, *Naja, nigricollis*, at Nasser, further up that river. In both these snakes the same parasite occurred, the infection being an exceedingly large one, about one corpuscle in every six containing parasites. In the case of *Naja nigricollis* a trypanosome (Plate XV., figs. 1, 2) occurred at the same time, while in both, a hæmogregarine (Plate XV., figs. 3, 4, 8) was also present.

In the fresh blood the parasite was seen in the corpuscles as large whitish areas dotted over with coarse pigment granules. The living parasites are figured on Plate XV., figs. 4, 5, 6.

PLATE XIV



C. M. WENYON — scale 10μ

1–17, 21 *Hæmocystidium najæ*, n. sp.

1. Male gametocyte staining red
2. Cell with two young forms
3. Male gametocyte staining pale blue
4. Triple infection of cell with young forms
5. Free female gametocyte in blood some hours after death
6. Male gametocyte contracted to spherical form in blood some hours after death
7. Female gametocyte showing karyosome
8. Male gametocyte and hæmogregarine
9. Pigmented leucocyte
10. Young parasite
11. Double infection of cell with male and female gametocyte
12. Double infection of cell with female gametocyte and hæmogregarine
13. Female gametocyte with red staining bodies on its surface
14. Female gametocyte showing karyosome
15, 16. Youngest forms without pigment
17. Young female gametocyte resembling gametocyte of quartan malaria
21. Young female gametocyte causing red cell to be drawn out at each end as in *Leucocytozoon* of guinea fowl

18–20 AND 22–24 HÆMOGREGARINE OF *Naja haje* AND *Naja nigricollis*

18. Small form of hæmogregarine
19. Encysted hæmogregarine free in plasma
20. Encysted hæmogregarine in red cell
22. Free hæmogregarine
23, 24. Two stages of schizogony from sections of lung

Watched for a long time the parasites exhibited no movements except a slight change in position of the pigment grains. Neither addition of citrate solution nor any other reagent brought about any changes comparable to the microgamete formation known to occur in other intra-corpuscular pigmented parasites. Blood taken from the snake some twelve or twenty hours after death revealed many spherical parasites free in the plasma. Whether this is to be explained as a process of development or merely as a dissolution of the red cells liberating the parasite cannot be stated.

Appearances in the fresh blood

In the films stained by Giemsa stain the appearances are much the same as have been described for the two species of *Hæmocystidium* already known. *Hæmocystidium* from the Indian river tortoise (*Chitra indica*) was described by Simond, and from the tree-dwelling gecko (*Hæmidactylus leschenaultii*) by Castellani and Willey. The name *Hæmocystidium* was created by these latter observers, for the parasites, owing to certain differences in their morphology from other intra-corpuscular parasites. A parasite similar to these has been described by Laveran from *Testudo pardalis* of South Africa. As in the case of *Halteridium* there are male and female gametocytes, and an absence of schizont forms. The gametocytes differ in size and shape from those of *Halteridium*, but this is insufficient ground on which to base a new genus. The fact that the parasite occurs in a cold-blooded host instead of a warm-blooded one is also a non-generic character. In the cases of such parasites it is necessary to know something more of the life-histories before it can be definitely stated that they belong to a distinct genus. However, till something more is known of their life-histories, the name *Hæmocystidium* may provisionally be accepted for these parasites till further observation confirms or contradicts this.

Appearances in the stained blood

On Plate XIV. the parasites are shown as they occur in films stained by Giemsa stain. The full-grown parasite is a large body of oval outline containing at its centre a nucleus of chromatin granules, and scattered about its substance coarse grains of pigment. As in other species of *Hæmocystidium*, the full-grown parasites may be differentiated into male and female gametocytes according as the protoplasm is dense or otherwise. Female gametocytes are figured in Plate XIV., figs. 7, 12. They stain a deep blue and have a nucleus at the centre consisting of granules of chromatin, one of which is differentiated as a karyosome. The pigment as coarse granules is either uniformly scattered through the cell, arranged in irregular clumps, or grouped at either end of the parasite, as is frequently seen in *Halteridium*. The male gametocytes are pale pink staining bodies. The chromatin of the nucleus may be central, as in the female gametocyte, or more scattered (Plate XIV., figs. 3, 8). The disposition of the pigment is the same as in the female forms. The gametocytes, when full grown, measure about 21μ by 14μ. In the blood taken from the snake some hours after death, extra-corpuscular forms are met with. A female gametocyte in this stage is figured in Plate XIV., fig. 5. Such forms show some resemblance to the female gametocyte of the quartan variety of malaria. At fig. 6 is a male gametocyte which has become spherical and has several chromatin granules. This shows some likeness to the early stages of microgamete formation in other similar parasites. In fig. 11 is a cell completely filled by a male and female gametocyte, while double infection of a cell with this parasite and the hæmogregarine is illustrated in figs. 8 and 12.

Gametocytes

The youngest forms of parasite met with are small masses of protoplasm with a single chromatin dot. Slightly more advanced forms show pigment in the form of a coarse granule and also frequently a vacuole (Plate XIV., figs. 2, 10, 15, 16). No forms were seen which could definitely be described as schizonts, though the presence of the young forms demonstrates that some form of multiplication must be taking place. Examination of the internal organs was fruitless in revealing what this multiplication was.

No schizonts observed

In some of the parasites a curious appearance is produced by the occurrence of red staining patches arranged over the surface of the parasite (Plate XIV., fig. 13). It cannot be stated whether this has any connection with the parasite, or is only a change in the corpuscle brought about by its presence.

Changes in the infected corpuscles

In several instances it was noticed that the corpuscles containing the parasite were drawn out at each end, just as occurs in the case of the *Leucocytozoon* of the guinea fowl (Plate XIV., fig. 21). Reference is made to this condition and its significance in the section devoted to the consideration of the parasite of the guinea fowl.

The uninfected corpuscles of the snake measure roughly 17μ by $8{\cdot}5\mu$, and these dimensions are considerably increased in the case of infected cells. The parasite tends to push the nucleus of the corpuscle to one side and also brings about some absorption of the hæmoglobin. Pigmented leucocytes (Plate XIV., fig. 9) are common in the blood. In sections of the liver and lung the capillaries are seen to be crowded with infected corpuscles, the capillaries being clearly defined by the pigment containing parasites. The endothelial cells of the vessels also contain pigment granules evidently derived from the parasites.

Clinging to the body of these snakes were ecto-parasites (*Gamasidæ*). Examination of these revealed nothing which threw any light on the affinities of this parasite.

For this parasite I suggest the name *Hæmocystidium najæ*, from its hosts, *Naja nigricollis* and *Naja hajæ*.

Babesia (Piroplasmata)

Babesia

Babesia avicularis, n. sp.

Host, *Avicularis zebræ*. Locality, Bor, Jebel River

Plate X., figs. 1–8

Piroplasm of the striped mouse

In a zebra mouse (*Avicularis zebræ*) taken at Bor on the Jebel River, was found an intra-corpuscular parasite of the genus *Babesia* (*Piroplasma*). A trypanosome (Plate X., fig. 9) was present at the same time. The zebra mouse thus infected was the first one examined, and though subsequently about two dozen others were captured and their blood submitted to examination, neither *Babesia* nor trypanosomes were met with again. As in other members of the genus *Babesia*, the parasite is found as a small unpigmented mass of protoplasm within the red corpuscles and having one or more granules of chromatin embedded in its substance. The parasite was only seen in the stained films. According to the appearances in these films the parasite exists in two forms, one of which is more compact and resembles the typical examples of *Babesia canis* or *Babesia bigeminum*, while the other is more irregular in shape, being evidently amœboid and resembling the irregular forms of the benign tertian variety of malaria. The two forms may be only the active and resting forms of the same stage of the parasite, or the irregular forms may be asexual stages, while the more compact forms are gametocytes.

Morphology of the parasite

The compact forms are shown in Plate X., figs. 2, 5, 6, 7. At fig. 2 there are two parasites in one cell, and the appearance produced reminds one of the similar condition in the case of *Babesia bigeminum* and *Babesia canis*. The forms depicted in figs. 5, 6, 7 show a marked likeness to some of the ring forms of the malarial parasites. In each is a vacuole on the surface of which the chromatin is arranged either as a line (fig. 7) or as a dot (fig. 5). In fig. 8 is shown a form which may be intermediate between these compact forms and the amœboid forms. A typical amœboid form is shown in fig. 1 and again in fig. 3. These bear a striking resemblance to the amœboid forms of the benign tertian malarial parasite. The parasite consists of irregular strands of protoplasm on which the chromatin is arranged in one or more clumps—multiplication apparently takes place by a process of budding, as in other *Babesiæ*. In fig. 1 is shown a form with four bud-like processes which are clearly comparable with the budding which takes place in the case of *Babesia canis*. For this *Babesia*, which differs from the only other species described from small mammals—viz. that described by Fantham from the rat and by Nicolle from *Ctenodactylus gondi* of Tunis—I suggest the name *Babesia avicularis*, from its host *Avicularis zebræ*.

HÆMOGREGARINA

Hæmogregarines

Hæmogregarina gracilis, n. sp.

Host, *Mabuia quinquetæniata*. Locality, Wau, Bahr-El-Ghazal Province

Plate XII., figs. 17–32; Plate XV., figs. 10, 13

A curious hæmogregarine of lizards

This curious hæmogregarine, which differs from any hitherto described species, was found in the same lizards in which the parasites named *Plasmodium mabuiæ* were discovered. The hæmogregarine has no connection with this last-named parasite, nor with the trypanosome which was occasionally found with it. The hæmogregarine is remarkable on account of its narrowness and the property it has of pushing out the corpuscle at either end, causing it to be much elongated. In many cases the corpuscular membrane is drawn tightly over the ends of the parasite. The effect is produced of a stiff rod within the corpuscle. It is common to find two parasites within one cell; rarely are three present. The parasite lies as a slightly curved rod along the long diameter of the cell (Plate XII., figs. 20, 21). Other forms of the parasite are met with in the blood, but the great majority are seen as these curved rods. The length of the hæmogregarine is 16μ or 17μ, with a breadth of about $1{\cdot}5\mu$. A delicate cyst encloses the parasite, as in other hæmogregarines. Within the transparent cyst the parasite appears as a narrow rod of protoplasm, staining a very pale blue. The nucleus is elongated and occupies about one third the length of the body. Some very fine red granules are often seen in the pale blue protoplasm. Sometimes the parasites are looped around the nucleus, but in such cases the cyst is also looped, and not the parasite within an unlooped cyst, as is usual with other hæmogregarines.

Encysted forms

Free forms

The cyst, with the parasite within it, may become free in the plasma, and, finally, by rupture of the cyst, the hæmogregarine escapes (Plate XII., fig. 17). Empty cysts are often encountered in the blood films. Unencysted parasites may also be seen within the corpuscles. These are sometimes elongated and like the encysted forms, but more usually they are contracted to bodies with an oval or circular outline (Plate XII., figs. 19, 26).

In the fresh blood the infected cells are seen to be deformed, being more pointed and longer than the uninfected cells. On careful observation the parasites are seen as very pale rods lying within the cells. In the fresh blood little of their structure can be made out. Occasionally parasites are seen free in the plasma, as very narrow hæmogregarines. The movements consist of a gliding forwards, a looping and unlooping, and a contraction and elongation of the body. From the appearances of the parasites within the cells, either in the fresh blood or in stained films, it would be difficult to form an opinion as to their nature, but the type of movement of the free forms is characteristic. The appearances of the parasite within the corpuscle is very constant, with the exception of the occasional occurrence of the rounded forms mentioned above. Nothing to be compared with sexual differentiation can be distinguished in the blood.

Schizogony cycle in the liver

In the liver, however, very different appearances are met with. In this organ the parasite is found to be multiplying rapidly by a process of schizogony. The smallest forms encountered are little spheres of protoplasm within the liver-cell, and having a diameter of $4 \cdot 2 \mu$. These bodies bear a close resemblance to the young stages of Coccidia. As in the case of the Coccidia, they are frequently seen lying in a kind of vacuole in the liver-cell. These young schizonts, for such they are, increase in size. In a more advanced stage two types of schizont may be differentiated, according to their shape. One is oval in outline (Plate XII., fig. 31), the other is more circular in outline (Plate XIII., figs. 23, 24). When the schizonts have reached a certain stage in their development, the nuclei commence to multiply. The nucleus consists of a pale-staining sphere, with a membrane in the centre of which is a deeply-staining karyosome. The nucleus divides by a form of mitosis, which very much resembles the division of the micronuclei of Infusoria (Plate XII., figs. 23, 24). In one form of schizont, which is probably the one of oval contour, the nuclear multiplication proceeds till about eight to sixteen nuclei are present (Plate XII., fig. 28). When this stage is reached, segmentation of the protoplasm takes place with the formation of a corresponding number of sausage-shaped bodies, which may be merozoites (Plate XII., fig. 27). Each of these merozoites has a nucleus with a distinct karyosome. In the case of the second kind of schizont, nuclear multiplication proceeds much further, with the result that an enormous number are produced (Plate XII., fig. 25). The nuclei are irregular in shape, and consist of a closely aggregated mass of chromatin granules. No definite karyosome can be distinguished. How nuclear multiplication takes place in these large schizonts has not been clearly made out. In the early stages, nuclear division appears to proceed as in the first kind of schizonts described above. Later each nucleus appears to be a mass of chromatin granules which becomes elongated and roughly constricted at the centre, giving rise to the irregular nuclei of the large schizonts. From the mass of protoplasm over the surface of which the nuclei are arranged there grow out finger-like processes of the protoplasm (Plate XII., fig. 30). Into each process passes one of the nuclei, which at the same time elongates, becoming much narrowed. Finally there are formed a large number of the narrow hæmogregarines which were first encountered in the blood. They are at first arranged regularly within the enveloping membrane (Plate XII., fig. 29), but later they have the appearance of a tangled mass (Plate XII., fig. 32). From the account of the two processes just given it seems as if two forms of schizogony are taking place—one resulting in the formation of macromerozoites, the other in micromerozoites. In each case, as the schizont enlarges, the liver-cell becomes very much distended, till finally there is nothing left but a membrane surrounding it, while at one side can be distinguished the nucleus of the liver-cell (Plate XII., fig. 31). The micromerozoites are very uniform in size, but there is some variation in the size of the macromerozoites.

Formation of merozoites

The cysts containing the merozoites were examined in the fresh condition, and the appearance is figured in Plate XV., figs. 10 and 13. If the cyst is ruptured by pressure on the cover slip, it is seen that the merozoites, both the large and small, crawl about exactly like hæmogregarines. Though the wanderings of these were followed for a considerable time, nothing like a sexual process was seen to take place. The micromerozoites passed over and under the macromerozoites and *vice versa* with the utmost impunity. Had they been differentiated gametes or anything of that kind, it would have been expected that some reaction would have taken place between them.

The occurrence of the two forms of schizogony in the liver with the production of the micro- and macro-merozoites is especially interesting, as only the micromerozoites are met with in the peripheral blood. It would appear that the macromerozoites live only in the liver-cells and there reproduce by schizogony, while the micromerozoites reproduce in the same manner and in the same situation, but also are able to attack the red blood-corpuscles. It has been stated uniformity in size is a feature of the intra-corpuscular forms, so that it cannot be assumed that they seek this situation for trophic reasons. It is possible that the forms in the blood are undifferentiated gametes, the end-product of a special sporogony in the liver, and that the larger forms really represent the asexual forms, which continue multiplying in the liver by schizogony.

Comparison with hæmogregarine of jerboa

In this connection it is interesting to recall the somewhat similar conditions of multiplication which are found in the life-history of *Hæmogregarina balfouri* of the jerboa. If the figures of the hæmogregarine at present under consideration (Plate XII.) be compared with the figures given by Balfour in his account of the hæmogregarine of the jerboa (Plate XII., Second Report, Wellcome Research Laboratories), the similarity will be at once evident. The differentiation into micro- and macro-merozoites is not so marked as in the lizard parasite, but it is still quite definite. There is the oval-contoured schizont which gives rise to three or four sausage-shaped bodies (in the lizard the number of these bodies is larger), while the spherical schizonts give rise to a number of small merozoites. Balfour seems to say that the oval schizont breaks up into the sausage-shaped bodies, each of which then grows into the large schizont which gives rise to the small merozoites which appear in the blood. A small merozoite from the blood is then supposed to attack a liver-cell and commence the cycle again by giving rise to the oval schizont. If this were the case, one would expect to find several of the spherical schizonts developing at one spot, as it can hardly be supposed that the sausage-shaped bodies would separate before growing into schizonts.

An asexual and a sexual cycle

In both cases it seems more probable that the two processes are independent of each other in so far as they do not represent part of one continuous cycle. There is probably a division or schizogony into macromerozoites and a schizogony into micromerozoites in exactly the same way as occurs in many Coccidia, in which case we must allow that only the micromerozoites gain access to the blood, or that there is an asexual cycle confined to the liver (the oval schizonts and sausage-shaped bodies of the two hæmogregarines) and a sexual cycle which gives rise to undifferentiated gametes, the sporogony taking place in the liver also, but the gametes taking up their position in the red blood-corpuscles. The continuation of the development might then be a conjugation of the gametes in some intermediate host. According to this latter view, there is a close similarity between this development and the life-cycle of the Schizogregarinæ as described by Léger and others. Association into pairs of the hæmogregarines of other animals has been described, both in the red-blooded host and also in the blood-sucking host. If this view holds good, the hæmogregarines of the blood would be the undifferentiated gametes or sporoblasts; but until something further is known of the life-cycles no definite conclusion can be arrived at.

For this hæmogregarine of the lizard, *Mabuia quinquetæniata,* I propose the name *Hæmogregarina gracilis,* on account of its narrow body and delicate structure.

HÆMOGREGARINES

Parasites belonging to this genus were discovered in a number of snakes and other animals. They will be referred to below under the names of their respective hosts.

1. *Naja hajæ* (Plate XIV., figs. 8, 12, 18–20, 22–24); *Naja nigricollis* (Plate XV., figs. 3, 4, 8).

Locality, River Sobat

This hæmogregarine occurs with a trypanosome and hæmocystidium in the blood of the spitting cobra. There are several distinct types of this hæmogregarine. (*a*) Looped form within cyst, staining a deep blue; nucleus round and compact; protoplasm free from granules;

length $12 \cdot 5\mu$, width $5 \cdot 5\mu$, the turned-up end about one-third length of cyst. This form is frequently seen in close apposition to the cell nucleus, which may be displaced, elongated, swollen or irregular in shape. (*b*) Pale form with clear protoplasm taking on a pinkish tint on staining, not looped within the cyst; length 14μ. (*c*) Small form (Plate XIV., fig. 18) measuring 7μ by 4μ. There is a large nucleus, composed of a spherical mass of chromatin granules, which occupies a great portion of the body of the parasite. Protoplasm stains blue, and shows distinct alveolar structure. This form is possibly a young schizont. (*d*) Free hæmogregarines about 15μ in length. The interesting point about this hæmogregarine is that in the lung the parasite reproduces by schizogony. As seen in sections the schizonts are large spherical bodies with many nuclei (Plate XIV., fig. 23). This body breaks up into numerous hæmogregarines (Plate XIV., fig. 24). The schizogony is remarkably like the similar stages of the hæmogregarine of the jerboa, as figured by Dr. Balfour in the Second Report of the Wellcome Research Laboratories, and resembles the schizogony of hæmogregarines described by Lutz and Laveran in the lungs of other snakes.

Hæmogregarine of the spitting cobra

2. *Atractaspis microlepidota.* Encysted hæmogregarine, looped within the cyst, which lies close to the nucleus of the host-cell. Nucleus of the parasite somewhat elongated. Measurement of the cyst, $15 \cdot 4\mu$ by $2 \cdot 8\mu$.

Hæmogregarines of various snakes

3. *Psammophis subtæniatus.* Hæmogregarines of this snake are encysted within the red cells. The cysts, which measure $11 \cdot 2\mu$ by $4 \cdot 2\mu$, displace the host-cell nucleus. They are very uniform in size and have a large nucleus of oval outline. A peculiar feature is that in the majority of infected cells there are present two structures which seem to have some connection with the parasite. One is a pale blue staining granule of about 1–$1 \cdot 5\mu$ in diameter, while the other is a granule of the same size but staining like the nucleus of the cell. These two bodies may occupy any position in the cell. Nearly all infected cells possess these structures, while they are found in only a few uninfected cells. It is possible that the latter cells have been deserted by their hæmogregarines. The nature of these bodies is not known.

4. *Psammophis sibilans.* In this snake is found a hæmogregarine of two distinct types encysted in the red cells. (*a*) Short form, measuring 11μ by $3 \cdot 5\mu$. Hæmogregarine looped within the cyst; protoplasm with red staining granules; nucleus almost spherical. (*b*) Longer forms $15 \cdot 5\mu$ by $3 \cdot 5\mu$; nucleus dense and compact; protoplasm clear, without granules. In either case the nucleus of the host-cell is frequently in contact with the cyst of the hæmogregarine and may be folded round it.

5. *Grayia tholloni.* The hæmogregarine of this snake is encysted and measures $11 \cdot 2\mu$ by 3μ. There is a great uniformity in the size and characters of these encysted forms. The hæmogregarine is looped within the cyst and has its nucleus near the bend. The protoplasm is very alveolar.

Marked changes are produced in the infected cells, which are increased in size and paler in colour. The paling occurs in patches, and appears most marked in the part of the cell not in contact with the cyst. The corpuscle may be very much creased and wrinkled while its nucleus is flattened and elongated.

6. *Chlorophys emini.* In this snake the hæmogregarines are found in several forms. There is a large form with alveolar protoplasm, and looped within the cyst. It measures $12 \cdot 2\mu$ by $4 \cdot 2\mu$. A small form occurs measuring $8 \cdot 4\mu$ by $4 \cdot 2\mu$, unlooped and with large nucleus occupying the greater part of the parasite. Intermediate forms between these two are found.

7. *Leptodira attarensis.* Hæmogregarines of two types. (*a*) Looped forms within cysts which measure $12 \cdot 6\mu$ by $2 \cdot 8\mu$; nucleus of parasite elongated. (*b*) Unlooped forms with very alveolar protoplasm and spherical nucleus; size, $11 \cdot 2\mu$ by $4 \cdot 2\mu$. The red cells are little changed apart from elongation and displacement of their nuclei.

PLATE XV

C. M. Wenyon

DRAWINGS FROM LIFE OF VARIOUS PARASITES

1–6, 8. FROM BLOOD OF SPITTING COBRA
(Naja nigricollis)

2. *Trypanosoma najæ*, n. sp. The characteristic spiral position of body is well shown
3. Hæmogregarine free in plasma leaving a trail of granules behind it as it progresses
4. Hæmogregarine and *Hæmocystidium* in same cell
Hæmocystidium najæ, n. sp., adult gametocyte
6. Young forms of *Hæmocystidium* in red cell
8. Hæmogregarine in red cell

7, 9, 11. *Trypanosoma mabuiæ*, n. sp., OF *Mabuia quinquetæniata*

10, 13. CYSTS FROM LIVER OF *Mabuia quinquetæniata*

10. Result of schizogony of *Hæmogregarina gracilis*, n. sp.—macromerozoites
13. Schizogony into micromerozoites

12, 14. *Hæmoproteus agamæ*, n. sp.

12. Maturation of the female gametocyte
14. Formation of microgametes from male gametocyte

8. *Python*, sp. Hæmogregarines of three types. (*a*) Common type; looped within cyst which measures $11{\cdot}2\mu$ by 3μ. (*b*) Large form with alveolar protoplasm; size $12{\cdot}6\mu$ by $4{\cdot}2\mu$. (*c*) Small stumpy forms, unlooped, and measuring $9{\cdot}5\mu$ by $3{\cdot}5\mu$.

Of tortoise

9. *Sternothærus adansoni*. In this tortoise taken in the Bahr-El-Ghazal, an encysted hæmogregarine was found in the corpuscles. The cyst measured $12{\cdot}5\mu$ by $5{\cdot}5\mu$. Within the cyst was a narrow hæmogregarine of approximately twice the length of the cyst, and doubled up so that the limbs of the loop were of equal length.

Of other reptiles

10. Hæmogregarines were also met with in the blood of the crocodile, the monitor (*Varanus niloticus*), and the toad (*Bufo regularis*) (Plate III., fig. 2).

Hæmogregarine in a fresh-water fish

11. In the fish *Ophiocephalus obscurus*, taken at Barboi Wood Station, there occurred a hæmogregarine and a trypanosome. The hæmogregarine is shown in Fig. 40. The corpuscle is enlarged and its nucleus displaced. The hæmogregarine measures about 6μ in length. Hæmogregarines from the eel have been described by Laveran and França. The eel is partly marine and partly fresh-water in its habits, while other fish found to harbour hæmogregarines are purely marine. As far as I know, the fish *Ophiocephalus obscurus* is found only in fresh waters. It will be seen from the figure of this hæmogregarine that it is very similar to the parasite of the eel figured by França. For this parasite I suggest the name *Hæmogregarina nili*.

LEUCOCYTOZOA

Leucocytozoa

Leucocytozoon Neavei

Hæmamœba Neavei (Balfour)

Plate XVI

This parasite was discovered by Sheffield Neave in the blood of the guinea fowl (*Numidia ptilorhyncha*) of the Sudan and described by him in the Second Report of the Wellcome Research Laboratories (*page* 200 *et seq*.). The *Leucocytozoon* was not studied by Neave in the fresh blood, and the figures given by him in his account of the parasite (Plate XX., Second Report of the Wellcome Research Laboratories) are of poorly stained specimens. In no case is the nucleus of the parasite clearly shown, and this has led to some confusion between the nucleus of the host-cell and that of the parasite. The figures showing various stages of division are really figures of parasites with pseudopodia or parasites deformed in the process of film-making. In one case, a kind of leucocyte, which is frequently seen in the blood films of guinea fowl blood, has been described as a product of the division of the parasite. Neave is, however, correct in adhering to the view that the drawn-out ends represent the altered host-cell, and not part of the parasite.

Leucocytozoon of the guinea fowl

In the Sudan I had good opportunity of making observations on this *Leucocytozoon*, and I was able to examine the parasite in the fresh blood and in stained films taken from numbers of guinea fowl, which were easily shot; also I had, in captivity, infected guinea fowl which were constantly examined. I had hoped to be able to discover the intermediate host of this parasite, but, though I had abundance of material, all my efforts in this direction were in vain. However, by the study of this parasite in the fresh blood, and in the stained films, I was able to convince myself on several points of interest. In the first place it was soon evident that great caution had to be exercised in judging the appearances of the parasite in the stained films, for it is remarkable the ease with which this parasite becomes deformed, altered in shape, and even separated from its host-cell in the process of making the films. It is only by careful examination of the fresh blood that one is enabled to avoid falling into error. Attention

PLATE XVI

(See opposite page)

1, 2, 4. Cells of guinea fowl blood, resembling red cells but without hæmoglobin. Possibly immature red cells. They may be drawn out at each end as in 1

3. Cell with young parasite in hollow of nucleus. This cell is much flattened on the film

5. Young parasite in spindle-shaped cell

6. Older parasite than in 5. Red staining line round the parasite well shown, and nucleus of parasite at its periphery appearing as if attached to line

7. Male gametocyte with red staining line round its edge. In the same cell are two Plasmodia, one on the left with a single chromatin mass, the other on the right in the stage of schizogony

8. Single cell infected with male and female gametocyte

9. Young parasite in spindle-shaped cell

10. Female gametocyte

11. Constricted parasite with two chromatin masses or possibly two parasites, line of separation not clearly shown

12. Immature male gametocyte showing well the red staining line around its periphery

13. Young form in spindle-shaped cell

14. Two young forms in one cell

15. Two male gametocytes in one cell

16. Parasite with two chromatin masses and lying in hollow of much enlarged nucleus

17. Male gametocyte free in plasma some hours after death

18. Female gametocyte free in plasma some hours after death

19. Young parasite in cell which is altered in film preparation

20. Female gametocyte—nucleus of which shows well the karyosome. The host cell shows longitudinal lining which may be much more marked than here represented

21, 22, 23. Small forms of Trypanosome

24, 25. Larger forms of Trypanosome

26. Female gametocyte

27. Fertilisation of female gamete by microgametes

28. Trypanosome intermediate between large and small forms

PLATE XVI

Scale = 10 μ

Leucocytozoon Neavei AND *Trypanosoma numidæ*, n. sp., OF GUINEA FOWL *(Numida ptilorhyncha)*

(See opposite page)

is drawn to this point because of the recently published account of a *Leucocytozoon* of the grey hawk (*Asturinnea monogrammica*) of the Congo, by Dutton, Todd and Tobey; in their description it is evident these authors have been led astray by the appearance of the parasite in the stained films, which were not controlled by observations on the fresh blood. The parasite is described as consisting of a periplast, an ectoplasm and endoplasm and nuclear bodies, while in connection with the nucleus there is described a complicated process of development of a structure called the "line." In one place it is said the host nucleus "has frequently been extruded, and gametocytes without any included host-cell nucleus are not uncommon." In another place "when matured parasites become rounded preparatory to conjugation, the periplastic sheath (fig. 77) is thrown off, together with the effete host-cell nucleus (fig. 31)"; and again the younger parasites are spherical—many figures indicate they are amœboid, and the presence of forms in plasm indicate that they may pass from cell to cell. "The younger parasites seem to apply themselves to (figs. 1, 4, 25) or to enter (figs. 13, 16) the host-cell. The larger parasites engulf them (fig. 26)." Such and other conclusions are made from the four stained films which these observers had at their disposal, and without any reference to the fresh blood, though some of the processes described are most involved and would require much more evidence to establish than can possibly be found in the limited material at their disposal. The great majority of the parasites figured in their plates are much deformed and distorted, for I have often seen such in badly prepared films from the blood of the guinea fowl. At another part of their paper (*page* 323), and in reference to another parasite, the above-named observers say: "We are fully aware of the necessity for caution in determining a developmental process from stained specimens," yet they do not hesitate to describe a complicated change as the development of the "line" and other processes from such material. It seems as if these authors have been unduly influenced by the cycle of development described by Schaudinn in a similar parasite, with the result that they have attempted to fit in with his description the appearances in their preparations. Their remarks on the *Leucocytozoon* are qualified by a footnote which reads: "The dangers of constructing a part of the life-history of a parasite from stained specimens alone are apparent," yet they are able to follow the development of the "line," the extrusion of the host-cell nucleus, the preparation of the gametocytes for conjugation, the amœboid character of the young forms, and the wanderings of the young forms from cell to cell, and finally the fact that the young forms "apply themselves to" or "enter the host-cell," while the older parasites "engulf them." Looking at the last of these points alone, reference to the figures given illustrating the processes of cell infection will show that these are quite inadequate and unconvincing and do not represent the processes ascribed to them. This is all the more clear when one bears in mind that all the figures quoted are of greatly altered parasites, and I may state at once that examination of the fresh blood of the guinea fowl rarely shows any but the typical spindle structure with the drawn-out pointed ends, and that in stained films, especially such as have not been well prepared, as a result of slow drying or other cause, distorted parasites are constant, and these correspond in every way to the figures given in Plate XX. of the paper by Dutton, Todd and Tobey. The figures on the other three plates illustrating this parasite are of less deformed parasites, though still so much altered that it is unsafe to draw from them any important conclusions. The staining is not good, and, as is common with blood parasites, distorted and squashed forms often stain in a curiously abnormal manner. The three observers at the very outset commence with a wrong conception of the structure of the object with which they worked. They have followed Schaudinn, who, we shall see, was quite wrong in his idea of the relations of the several parts of the parasite and host-cell. Descriptive names for the several parts have been given, and as these depend on their erroneous view as to the meaning of the different structures encountered, they will have to be abandoned.

Criticism of recent work on a *Leucocytozoon*

If one examines the fresh blood of an infected guinea fowl, elongated spindle-bodies of various sizes will be seen. In each spindle-body can readily be distinguished the three well-known parts characteristic of these parasites. The nucleus of the host-cell is a granular body at the middle of the spindle and usually lying at one side, though this is not invariably the case. It is somewhat flattened. Touching the nucleus on one side, and extending beyond it towards each end of the spindle, is a large refractile body, more homogeneous than the host-cell nucleus, but still containing in its substance some highly refractile granules of a greenish tint. True brown melanin pigment was never present. This body has been variously described as the parasite itself or only the endoplasm of the parasite. The former view we shall find to be the correct one. Extending beyond the parasite are the drawn-out ends of the spindle. This part is much less refractile than the body of the parasite, and does not contain granules. The ends may be very much drawn out, so as to resemble fine whip-like organs. The surface of the whole spindle-body is differentiated as a fine membrane—the periplast of Dutton, Todd and Tobey. This membrane is exactly comparable to the membrane which encloses an ordinary red blood-corpuscle, and is to be regarded merely as the differentiated superficial layer of the host-cell. As has already been mentioned, in the fresh blood it is unusual to find any but the spindle shape. In blood taken from a guinea fowl some time dead, or in wet films an hour or two old, the spindle shape has frequently been lost and the parasite and host-cell have become quite irregular.

Appearances in the fresh blood

Movements of the parasite

In the fresh-blood preparations, especially if kept at body temperature, the parasites within the spindle-bodies are seen to exhibit movements. These consist of slight elevations of the surface of the body hardly large enough to be called pseudopodia. In addition, there is a second kind of movement in the form of waves of constriction, which commence at the middle of the parasite and pass first towards one end and then towards the other end of the spindle. Each wave drives the protoplasm of the parasite before it as a fine process into the very tip of one end of the spindle. As the protoplasm is passing before the wave into one tip of the spindle, behind the wave the protoplasm is flowing out of the opposite tip. The same process is repeated in the reverse direction after a few seconds' rest. It will thus be seen that the protoplasm of the parasite is alternately driven into, and withdrawn from, the points of the spindle, and it may be that this circumstance has something to do with the peculiar shape of the host-cell. As the parasite flows in and out of the spindle ends, it may have the effect of producing a to-and-fro movement of the fine whip-like extremities which has some superficial resemblance to the movements of a flagellum. This motion, however, on the part of the host-cell is quite passive.

A further point which can be made out from the living specimens is that the spindle-bodies are in reality flattened or leaf-like. A transverse section through the middle of the spindle would not be circular in outline, but oval. Beyond the parasite the drawn-out ends of the host-cell are still more flattened, and this point is very suggestive as to the kind of cell infected being a flattened cell of the nature of a red blood-corpuscle or one of the cells resembling it.

Escape of parasite from host-cell

The movements just described will continue on the slide for three or four hours. In the case of the larger parasites—the gametocytes—the host-cell frequently ruptures, and eventually the parasite escapes and becomes spherical. This process is exactly comparable to the escape of the gametocytes of other intra-corpuscular parasites, such as *Halteridium*, *Proteosoma* or the malarial parasites. After escape slight changes in shape take place for some time, and eventually the parasites become quite still and die. In the fresh blood I did not see the formation of microgametes nor the "travelling vermicule" stage as described by Danilewsky and others for similar parasites. However, in the stained films some of these forms were discovered.

Experiments were conducted with numerous mosquitoes of the genera *Mansonia, Tæniorhynchus, Culex, Myzomyia, Pyretophorus* in order to determine the intermediate host, but with no result. Only those changes seen to take place in the fresh blood were again encountered in the stomachs of the mosquitoes. It is possible that the intermediate host is not a mosquito at all, but that some other fly is responsible, as the Sergents and Aragao have demonstrated in the case of *Hæmoproteus columbæ*. No intermediate host found

The infection varied very much in different guinea fowl. In old birds, as a rule, the infection was small, while young birds harboured the largest number of parasites. It is very probable that the young birds become infected soon after hatching, and that the infection gradually gets smaller with increase in age. In almost every bird prolonged search would reveal at least one or two parasites. In the majority of birds *Halteridium* was present at the same time, and very commonly filaria embryos. In one, *Proteosoma* was found, while in two, trypanosomes occurred with the *Leucocytozoon*. It is interesting to note that, though practically all guinea fowl were infected with the *Leucocytozoon*, only two revealed this parasite and trypanosomes at the same time. The trypanosomes have been described at another part of this Report, but though superficially there is a certain resemblance between the trypanosomes and the spindle-bodies, this is only accidental, and the two parasites have nothing whatever in common. Intensity of infection

There have been two main views advanced as to the structure of the spindle-bodies. In one case the whole structure has been represented as a parasite which has engulfed a leucocyte, the nucleus of which is visible at the side of the parasite. This only applies to the older parasites. The younger forms are supposed to enter a leucocyte. This view was expounded by Schaudinn, and has been supported by Dutton, Todd and Tobey. The second view, and the one which is undoubtedly correct, is that the denser portion which surrounds the host-cell nucleus represents the whole of the parasite, while the drawn-out ends of the spindle-body represent the drawn-out ends of the host-cell. The parasite is like a *Halteridium* which lies around the host-cell nucleus. The second view is supported by Laveran, Berestneff, Sakharoff and others, and is the only one which can possibly explain the appearances. The first view seems to have been evolved by Schaudinn to fit in with his conception of the relationship between *Leucocytozoon* of the little owl and the trypanosome, in spite of the fact that nothing of a similar nature was known to occur with other blood parasites and the absence of evidence that trypanosomes would behave in the manner he described. Structure of the spindle-bodies

In support of the second view many facts come to light from a study of the parasite of the guinea fowl. Nature of the spindle-bodies

1. The character of the movements which have been described as taking place in the fresh blood. It is only the true parasite that moves. The host-cell may move, but this is purely passive motion. The escape of the gametocytes from the cell takes place in precisely the same way as the escape of the gametocytes of *Halteridium*.

2. The occurrence of two parasites in one cell occurs commonly in the case of the guinea-fowl *Leucocytozoon*, as has been noted by other observers in the case of other *Leucocytozoa*. It might be suggested that a division had taken place in the endoplasmic portion, but such an explanation could not possibly hold in those cases where one cell contains both a male and female gametocyte. On Schaudinn's hypothesis one would have to assume that two trypanosomes had engulfed one leucocyte between them, which is absurd.

3. In one bird *Proteosoma* occurred together with the *Leucocytozoon*. Examination of films showed that in many cases the spindle-bodies were infected with the *Proteosoma*. It was only in the part of the cell beyond the *Leucocytozoon* that these parasites occurred. They were quite normal and developing in the same manner as the forms present in the red corpuscles at the same time. Plate XVI., fig. 7, shows such a double infection. In one

extremity of the spindle-body a *Proteosoma* is in the stage of schizogony, while at the other end is a parasite which has not yet reached this stage. If the whole spindle-body were the parasite, one would have to conclude that here is an illustration of one blood parasite parasitic on another, or, in other words, a *Proteosoma* parasitic on a trypanosome. This view is quite inadmissible, as this is merely an infection of one cell by two different parasites.

4. In several instances forms were seen which did not have the regular spindle structure. These are simply large cells of oval outline having the parasite curled round the nucleus. Apart from the size and the fact that there is no pigment these forms could readily be mistaken for *Halteridium*, but the character of the parasite leaves no room for doubt; this is only a much enlarged cell infected with the *Leucocytozoon* which has not produced the characteristic change in shape of its host-cell.

The host-cell, a peculiar form of erythrocyte

5. The peculiar spindle shape of the host-cell has caused some confusion, and various theories have been advanced to overcome this difficulty. Most observers describe the cell as a leucocyte of some form. Laveran first suggested it to be a much altered erythrocyte, while others assert that it is an erythroblast. Above, attention has been drawn to the peculiar movements of the parasite within the cell and the waves which pass along its body towards the spindle ends, thus possibly helping in the production of the drawn-out processes. The type of cell infected also aids in the production of this shape. In the blood of birds and reptiles there are many cells of oval outline, which vary in size, but on an average approach the dimensions of the red blood-corpuscles. These cells possess no hæmoglobin, and their nuclei resemble in many ways the nuclei of the red blood-corpuscles. A peculiar feature of these cells—which may be young or immature red cells—is the property they have of being drawn out at each end. Such cells have been figured in Plate XVI., figs. 1, 2, 4. A cell of this type from the blood of the vulture has been figured in Plate XVII., *f*, in the Second Report of the Wellcome Research Laboratories. An examination of a large number of slides in which young forms of the *Leucocytozoon* were present shows clearly the relation existing between these peculiar cells and the spindle-bodies. The tendency of these cells to become spindle-shaped apart from infection explains to some extent the spindle shape of the infected cells. A comparison of the uninfected cells (Plate XVI., figs. 1, 2, 4) with the young forms on the same Plate (figs. 5, 6, 9) will show clearly the relationship between the two. The fact that it is a cell devoid of hæmoglobin which is infected explains the absence of pigment in the *Leucocytozoon*.

6. In the case of *Hæmocystidium najæ*, the pigmented parasite of the red cells of the African cobra, one occasionally sees the infected red cells drawn out into spindle-shaped structures resembling very much the spindle-bodies of the guinea fowl (Plate XIV., fig. 21).

From a consideration of the above points it seems to me quite clear that no other hypothesis explains the case than that the *Leucocytozoon* infects a cell in the same manner as occurs with every other known intra-corpuscular parasite, and, as a matter of fact, no other hypothesis would be required apart from the endeavour to draw a comparison between these spindle-bodies and trypanosomes. It is quite evident that Schaudinn was mistaken in the description of the *Leucocytozoon* with which he worked, and likewise Dutton, Todd and Tobey in their account of the similar parasite of the grey hawk from the Congo.

Two main types of parasite

As described by Neave two main types of parasites are encountered in the blood, corresponding to male and female gametocytes. The female forms (figs. 8, 10, 20) have a dense protoplasm which stains deeply with Giemsa or Leishman stain. The male gametocytes (figs. 7, 8, 15) have a protoplasm which stains less deeply. These two forms correspond closely with the male and female gametocytes of *Halteridium*. The absence of pigment can be accounted for by the absence of hæmoglobin in the infected cells. There are also differences in the nuclei. The nucleus of the female gametocytes consists of a group of chromatin granules usually closely

Gametocytes, male and female

arranged at the centre of the parasite. One of these granules is markedly larger than the others. It may lie in the centre of the smaller granules or may be separated from them. It is probably a karyosome, and the separation of this karyosome from the rest of the nucleus may be a stage in a maturation process. In the male gametocyte the chromatin granules of the nucleus are as a rule much more scattered through the cell, and there is no granule which stands out clearly as the karyosome of the female gametocyte. The karyosome of the female gametocyte suggests the micronucleus of a trypanosome, and when this karyosome is separated from the rest of the nucleus the resemblance is still more marked. There is nothing, however, to support this view or to show that this is more than a chance resemblance. Together with the two forms which have just been described as male and female gametocytes there occur also in the blood much smaller forms (figs. 5, 6, 9, 13), which possibly are young gametocytes. Careful search through many films made from large numbers of guinea fowls, and examination of the blood of the same birds from day to day, have not revealed any asexual multiplication forms any more than similar search for the asexual forms of *Halteridium* has resulted in the discovery of the asexual forms of this parasite. In Plate XX., figs. *c*, *c′*, *d* and *e*, of his account, Neave reproduces what he calls various stages of division. There can be no doubt that these are merely deformed parasites, and do not represent division stages, as I have pointed out above. Schaudinn explains the absence of division forms by supposing that the parasite escapes from the cell and becomes a trypanosome, and that asexual reproduction proceeds only in the trypanosome stage. In the case of the guinea fowl parasite there is nothing to uphold this assumption. In some of the smaller forms appearances as shown in figs. 11 and 14 are seen. Fig. 11 can easily be interpreted as a double infection, and fig. 14 as another case of the same kind where the line of demarcation between the two parasites is not clearly defined. It would appear, then, that in the peripheral blood, as in the case of *Halteridium*, no asexually reproducing forms are encountered. As this parasite so closely resembles *Halteridium*, it is probable that the forms in the blood are young or fully developed gametocytes, and that the asexual reproduction is to be sought for in the internal organs, and will possibly be of the same kind as the recently discovered asexual reproduction of the *Halteridium* of the pigeon (Aragao). Examination of the internal organs of the guinea fowl has revealed nothing, but it would be necessary to inoculate uninfected guinea fowls and to study the early stages of infection, when asexual reproduction would be proceeding rapidly. I inoculated domestic fowls and other birds with guinea fowl blood, but obtained no results.

No asexual multiplication forms discovered in the peripheral blood

In the description of the parasite of the grey hawk, Dutton, Todd and Tobey lay much stress upon the development of what they call the "line." They have traced its development from a granule in the nucleus. Appearances like those represented in their figures I have met with in the case of the guinea fowl parasite. Sometimes some of the chromatin is arranged as a short line, but, though I have examined a large number of slides, I have not been able to trace out anything like the development given by these observers. It is a significant fact that, in the greater proportion of their figures illustrating this development, the parasites are much distorted. In the development of the "line" it is finally traced on to what these observers call the ectoplasm, which, as we have seen, is not part of the parasite, but merely the host-cell. In this case at any rate the "line" cannot be part of the parasite, unless we conclude that it has been thrown out from the body of the parasite. But it is probable that several appearances have been confused and together described as the "line." I have mentioned the fact that the chromatin of the nucleus may sometimes be arranged in a line and the karyosome itself may be elongated. This would correspond with the earlier stages of development of the "line." In many of the guinea fowl parasites the margin round the parasite stains a deep red like the staining of the chromatin. This appears in

Appearances in the stained blood, the so-called "line" favourable examples as a red line extending all round the parasite (fig. 12). In other cases the line does not extend all the way round the parasite, but only on that side opposite the host-cell nucleus (fig. 6), and in those parasites where the nucleus lies against this side it might easily be supposed that there is some connection between this line and the chromatin of the nucleus. Figs. 24, 27, 32 of Dutton, Todd and Tobey show such a parasite in which the red line at the margin of the parasite has been interpreted as the "line" arising from the nucleus.

The true nature of the "line"

If now attention is turned to parasites which are altered in shape or distorted, it will be noted that this line, which in reality lies round the margin of the parasite, takes up various positions in the cell, and may lie across the middle of the parasite. In such cases it would be easy, if material is limited, to miss the true nature of this line. Further, owing to a longitudinal creasing of the host-cell, which sometimes occurs in preparations, various red staining lines appear which extend across the parasite from the host-cell, and may even produce appearances of longitudinal division of the "line."

After examination of a much greater amount of material than was possible for them, I am convinced that the description of the development of the "line" given by Dutton, Todd and Tobey is an erroneous combination of the appearances of several distinct objects produced by the distortion of the parasites in the blood films examined. It may be mentioned here that the red line which appears round the parasite as in figs. 6 and 12 is probably due to the fact that the spindle-body is flattened or leaf-like, and is not cylindrical. This flattening is not due to the spreading of the film, but is equally observed in the fresh blood. The red line appears at the edge of the parasite, which is really a flattened piece of protoplasm.

The nucleus of the host-cell

The arrangement of the nucleus of the host-cell in reference to the parasite varies very much. In some cases it is much elongated (figs. 11, 15), in others it is little altered in shape, while in some it tends to surround the parasite (fig. 19). At fig. 3 is depicted a small parasite indenting the nucleus, and the same appearance at fig. 16. Generally speaking, the smallest parasites that could be detected were seen lying against the nucleus of the host-cell in the manner just described. The staining of the host-cell nuclei varies greatly. In the youngest forms observed (Plate XVI., figs. 5, 6) the staining is exactly like that of the nuclei of the uninfected cells (Plate XVI., figs. 1, 2). As the parasite grows the cell enlarges and the nucleus with it. At the same time the nucleus is altered and stains differently, so that care must be exercised in attempting to judge of the type of cell infected from this enlarged and altered cell. It resembles more a mononuclear leucocyte, and it is this fact that has probably led to the host-cell being described so often as a leucocyte.

The movement of the gametocytes in the fresh blood has been described above. Fig. 18 shows a female gametocyte which has escaped from the host-cell, and fig. 17 a male gametocyte. In no case, either in stained films or in fresh blood, has the formation of the microgametes been observed, but in one film several appearances like the one depicted in fig. 27 were encountered. In the same film *Halteridium* occurred together with the *Leucocytozoon*. The large body depicted is undoubtedly the macrogamete of the *Leucocytozoon*, and unless the microgametes are those of *Halteridium* this is the fertilization of the female gamete. It is improbable that the microgametes of *Halteridium* would cluster round the macrogamete of another parasite, and as this figure resembles that given by Schaudinn of fertilisation in the parasite of the owl this is probably the correct view. In Schaudinn's figure the microgametes are shown as small trypanosomes with an undulating membrane. In this case the microgametes show nothing of the trypanosome structure after the most careful examination. They resemble the microgametes of the malarial parasites, and consist of a protoplasmic portion with chromatin arranged longitudinally.

The appearances of this parasite have been dwelt upon at some length on account of its connection with the similar parasite of the little owl with which Schaudinn worked. Though in some instances there is a certain resemblance between the parasite plus its host-cell and the trypanosomes, there is nothing to uphold the view that the two are in any way connected. Many facts have been brought forward in this paper showing conclusively that Schaudinn was mistaken in his idea of the relations existing between the host-cell and the parasite, and if he could be mistaken in a point so fundamental one hesitates to accept the remainder of his description. It has recently been shown that *Halteridium* may reproduce in a manner quite otherwise to that described by Schaudinn. His work has as yet received no conclusive support from any quarter, but many observers have brought forward evidence opposing his views. Apart from the correctness or otherwise of these ideas, it seems to me premature to accept Schaudinn's statements as finally proved, and to take as types of the development of trypanosomes the two parasites which Schaudinn investigated and about which there has been so much dispute. It would be safer to wait till more confirmatory evidence has accumulated before making fundamental alterations in our conceptions of the relationship existing between trypanosomes and the intra-corpuscular blood parasites. It may be that many of these parasites have a flagellate ancestry, but it must be remembered that even if this be the case the two groups may now be sufficiently far apart to constitute distinct classes. Before grouping them together in a classification it must be shown that the two forms occur in the life-history of a single parasite, as Schaudinn has attempted to do for the parasites in the little owl. His observations are in great part erroneous, and unless his views are accepted as correct, in spite of evidence to the contrary, there is no known intra-corpuscular blood parasite which has a definite flagellate stage in its life-history. The parasite of kala-azar, the Leishman-Donovan body, is really the resting stage of a flagellate, and is not to be confused with other intra-corpuscular blood parasites. The parasites of the malarial fevers of man and birds, *Halteridium*, and the parasite described in this report as occurring in the blood of the lizard *Agama colonorum*, and many other parasites closely related to these, show features common to themselves and also with the Coccidia, and there is much to be said in favour of the grouping together of these forms with the Coccidia. Other blood parasites, such as those belonging to the genus *Babesia*, are separated more widely from the Coccidia, and in the absence of pigment approach more to the Hæmogregarines, which in many respects show affinities with the Schizogregarinæ.

No connection between these parasites and trypanosomes

Schaudinn's erroneous conclusions

Leucocytozoon in Francolin Partridge

In a Francolin partridge shot at Bor on the Jebel River I found a parasite resembling closely the *Leucocytozoon* of the guinea fowl. In the blood male and female gametocytes were present, and from the material at my disposal (one dead bird) it could not be distinguished from the parasite of the guinea fowl.

Leucocytozoon in a partridge

HELMINTHES

Helminthes

A collection of parasitic worms was made. These consisted of Cestodes, Nematodes, and Trematodes from various animals. Filaria embryos were found in the blood of the toad (*Bufo regularis*), the lizard (*Agama colonorum*), the Francolin partridge, the guinea fowl (*see* paper by Sheffield Neave in the Second Report of the Wellcome Research Laboratories).

Parasitic worms

In a donkey, which I had taken up from Khartoum, I found a single filaria embryo after returning from the Bahr-El-Ghazal Province. The embryo had no sheath, a sharp tail, and was very active. At its anterior end there was a rod-like structure, which was extruded and retracted alternately. The length of this embryo was 224μ. Further examination of the blood at repeated intervals failed to reveal any more embryos.

Filariasis in donkey

Though the blood of hundreds of natives was examined, only on one occasion were

Human filariasis

filaria embryos found. This was in a man admitted to the Wau hospital. He had *Filaria perstans* in the blood, and was also suffering from marked lymphatic leuchæmia. A blood count showed 4,770,000 red cells, and 354,000 whites. The increase in the white cells was due solely to the presence of small lymphocytes. The spleen was enormously enlarged, extending across the middle line of the abdomen and into the right iliac fossa. This patient was not a native of the Sudan, but had come from the south.

Nematodes in mosquitoes

Finally, it may be mentioned that in the dissection of mosquitoes encysted nematodes, probably filaria embryos, were found on one occasion in the thoracic muscles of *Tæniorhynchus tenax*. This was at Nasser, on the Sobat, and I thought that possibly this was a stage in the development of the filaria of the toads which were infected at this place. This mosquito and others fed on infected toads gave only negative results. The embryos all appeared to die in the stomachs of the mosquitoes. The presence of the filaria embryos in *Tæniorhynchus tenax* is interesting in the light of Low's discovery of similar nematodes in another species of Tæniorhynchus—*Tæniorhynchus fuscopennatus*.

The collection of parasitic worms I have handed over to Dr. Leiper, Helminthologist to the London School of Tropical Medicine, who has kindly consented to examine the material. An account by him will be found at another part of this volume (*page* 187).

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FIG. 41.—YABUS RIVER, BURUN COUNTRY

On Some Interesting Reptiles collected by Dr. C. M. Wenyon, on the Upper Nile

BY

Doctor Franz Werner

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During his stay at different stations of the Upper Nile and Bahr-El-Ghazal Provinces, for investigations on blood-parasites, Dr. Morley Wenyon, of the Wellcome Research Laboratories, Khartoum, and the London School of Tropical Medicine, collected a number of reptiles, and, when returning home, was so kind as to pay me a visit in Vienna, on March 20th, 1908, where I had the pleasure of examining the very interesting collection of reptiles he had made in the Sudan. I am very grateful to him for the gift of the whole material, to which the following notes refer :— Reptiles

Turtles

Cyclanorbis oligotylus, Siebenrock

A fine young specimen from Nasser, Upper Sobat. It is coloured rather similarly to the larger one brought home by myself from Khor Attar.

Lizards

Agama hartmanni, Peters

A male from Taufikia; total length 208 mm., tail 133 mm. I must confess that I can *Agama hartmanni* no longer have doubts about the occurrence of this species in the Upper Nile Valley, although I expressed such in my publication on the Sudan Reptiles (*Sitz. Ber. Akad. Wiss. Wien*, Vol. CXVI., 1907, page 1836). The specimen before me shows all the characters that distinguish the typical specimen in the Berlin Museum from *A. colonorum*; the snout being without an elongate, enlarged and longitudinally-keeled scale on the median elevated crest; nasal short, nostril in the middle, pointing backwards; spines around the ear very few and minute; lateral scales not smaller than dorsals, less distinctly mucronate.

Brown above, with a yellow median line on the back and a row of yellow, elliptical, dark margined spots on each side; similar, but much less distinct, spots below them. Habit more slender than in *A. colonorum*. Præanal scales, 10.

Agama colonorum, Daudin

A male (October 14th, 1907) and a female (August 27th, 1907), from Wau (Bahr-El-Ghazal); similar to my specimens from Mongalla and Gondokoro. The species has been already recorded from the Bahr-El-Ghazal (Meshra-El-Rek) by Heuglin.

Varanus niloticus, Laurenti

A young specimen from Wau (September 20th, 1907).

Mabuia quinquetæniata, Lichtenstein

Two males and a female from Wau, Bahr-El-Ghazal Province. Scales round the body, 36-38; præfrontals in contact in all specimens. Throat of adult male deep black.

Dr. Wenyon has kindly given me the following notes regarding the adaptation of this lizard to the colour of its surroundings :—

"The male lizard (*Mabuia quinquetæniata*) is curiously marked, having the anterior half of its body green, dotted with black spots, while the posterior half, including the tail, is orange-coloured. This marking seems to be dependent on colours prevailing in its habitat. At Wau there is a large quantity of ferruginous rock of an orange-red tint, which is more or less covered with green grass and foliage. The lizards in question delight to sit upon this rock, basking in the sun or watching for an opportunity of licking up some fly that settles near. In this position the lizards are easily overlooked, for with their orange tails and posterior half of the body lying on the rock and the green anterior half of the body slightly raised, and perhaps looking through some green grass, there is a very perfect illustration of protective resemblance. Whether this colouring of the lizard is peculiar to Wau or not I cannot say, for I have not seen the reptile elsewhere, but in any case at this place the lizard seems to be distinctly protected on account of the resemblance between its own colouring and that of its surroundings."

CHAMÆLEONS

Chamæleon gracilis, Hallowell

Chamæleon gracilis

A half-grown male of this species, which has not been previously recorded, from the Egyptian Sudan, though it is common at Gondokoro, likewise from Wau.

SNAKES

Tropidonotus olivaceus, Peters

Several specimens from Wau.

Boodon lineatus, Dumeril and Bibron

A young specimen from Wau, September 23rd, 1907—belonging to the longitudinally striped form—body uniformly light brown above. This is the "Jaggar" snake, believed to be highly poisonous by the natives of many districts of Africa. Perhaps this opinion has been caused by the very strong, but solid, fangs of the upper jaw. All specimens known to me from the Sudan are referable to the var. *Cipræocularis*, Gthr., especially distributed in East Africa, but the markings of the head are more as in the South and West African specimens.

Chlorophis emini, Günther

Two specimens from Barboi, Upper White Nile, November 6th, 1907. Ventrals, 189; subcaudals 90 pairs (tail incomplete), and ventrals 188; subcaudals 132 pairs. There is no longer any doubt on my part that this snake does not occur so far north as Khartoum, as believed by Anderson.

Grayia tholloni, Mocquard

Mocquard, *Bull. Soc. Philom.*, Paris (8), IX., 1896-7, page 8.

Boulenger, *Ann. Mus. Congo* (I.), II., 1, page 9, Plate III., fig. 3.

This species, originally described from the French Congo by Mocquard, afterwards from the Congo State (Lake Tanganyika), as *G. fasciata* by Boulenger, has since been found at Entebbe, Victoria Nyanza, and at Polkom, Sobat, but is new for the Egyptian Sudan. Dr. Wenyon got two specimens at Barboi, south of Taufikia, White Nile; both are males. Ventrals 135-170; subcaudals (?) (tail mutilated in both specimens, as frequently in the long-tailed species of *Grayia*). From snout to vent., 565 mm.

Greyish-olive above, the scales edged laterally with white, most of the lateral scales with a black spot at the tip; yellowish below, the ventrals laterally with a black spot at their posterior margin. Labials broadly edged with black. Young with dark cross-bars.

The number of ventrals varies, according to the communications of my friend Boulenger, from 135 (Entebbe, Barboi) to 143 (Tanganyika, Polkom); the number of subcaudals from 100 to 111. Teeth in the upper jaw, 27 to 30. The smooth, relucent scales and the very long tail are characteristic of this, probably, aquatic snake.

Leptodira attarensis, Werner

An adult and two young specimens from Barboi, White Nile, agreeing perfectly with the types from Khor Attar; only the adult differs in having two præoculars—the upper, however, not reaching the frontal. Possibly this species is identical with *L. degeni*, Blngr., the description of which I overlooked when preparing my synopsis of the African *Leptodira*.

Psammophis sibilans, Linnæus

Plate XX., fig. 3

Three specimens—a young, a half-grown (Barboi), and an adult; the latter 1·52 metres long (Bor); all belonging to the large aquatorial variety.

Psammophis subtæniatus, Peters

A male from Wau, new for the Egyptian Sudan. Total length, 870 mm.; tail, 300 mm,; *Psammophis*
number of ventrals, 165; of subcaudals, 113 pairs; eight upper labials, fourth and fifth entering the eye; three to four lower labials in contact with the anterior chin shields.

This species, known hitherto from East Africa south of the Equator and from German South-West Africa (Boulenger, *Cat Snakes* III., p. 160; and Werner, *Verh. Zool. bot. Ges. Wien*, 1902, p. 370), is very similar to the preceding species, and, indeed, without comparing specimens, it will not be easy to distinguish them.

P. subtæniatus is more slenderly built than the Sudanese *P. sibilans*; the head is also narrower, the rostral somewhat broader than deep (as deep as broad in *P. sibilans*), the loreal more elongate, and the coloration resembles more that of *P. schokari*, especially the markings of the head. Upper lip and lower surface of head in the Wau specimen, uniform white. A dark brown band, seven scales wide, along the middle of the back, divided by a narrow yellow median line; a black line on each side on the first row of scales. From here the brown colour of the sides clears up to yellowish at the outer margin of the dark dorsal band. A ferruginous brown longitudinal line on each side of the ventrals and subcaudals to the end of first half of tail.

The four species of *Psammophis* found hitherto in the Egyptian Sudan may be distinguished as follows:—

I. Scales in 15 rows ... ... *P. biseriatus*, Peters.
II. ,, 17 rows (exceptionally 19)
  1. Upper labials, nine ... ... *P. schokari*, Forskal.
  2. ,, ,, eight
    a. Rostral, broader than deep ... *P. subtæniatus*, Peters.
    b. ,, as deep as broad ... *P. sibilans*, Linnæus.

Naja nigricollis, Reinhardt

Plate XVIII., fig. 2

A specimen from Taufikia, White Nile, 1270 mm. long (tail 200 mm.) Scales, 25, on the neck as well as on the middle of the body. Ventrals, 201; subcaudals, 55 pairs; upper labial, 6 to 7; præoculars 2, postoculars 3, temporals 2 + 5. Head, light brown above; body, greyish-olive; upper labials and lower surface of head, dark grey; symphysial and posterior chin-shields, whitish; the 17 anterior ventrals, black; the following four, yellowish; and, again, four and a half, black; from here the yellow and black rings become indistinct and the ventrals become grey-olive with a light greenish-olive posterior margin.

Causus rhombeatus, Lichtenstein

Plate XVII., fig. 3

ausus hombeatus

A young specimen from Taufikia, new for the Egyptian Sudan.

Ventrals, 136; subcaudals, 22 pairs; 6 upper labials.

Oculars: 2 præ-, 2 sub-, 1 postoculars on the left.

2 præ-, 3 sub-, 2 postoculars on the right side.

Differs from the following species in coloration in the brownish-grey ground colour, the larger dorsal spots, the missing black margins of upper labials and different position and shape of the nuchal Λ-shaped marking.

Causus resimus, Peters

Plate XIX

ausus simus

Three specimens, perfectly adult, from Taufikia, White Nile, the largest 670 mm. (tail 70 mm.). Keels of scales very distinct, not reaching much beyond the basal half of the scale; even the keels of the outer row distinct. Scales in 21 rows; ventrals, 148, 149, 155; subcaudals, 26, 23, 20 pairs. The total sum of ventrals and subcaudals (174, 172, 175) varies, therefore, less than the sum of ventrals or subcaudals taken separately (3 instead of 6 or 7); a similar number results from the specimens recorded by me in my "Reptiles of the Sudan" (173, 177).

The coloration is distinctly green in life, bluish in spirit.

Upper labials, 7; oculars:—

1. 2 + 2 + 2, 2 + 1 + 1.
2. 2 + 1 + 1, 2 + 1 + 1.
3. 2 + 1 + 1, 2 + 1 + 1 (on the left side, two postoculars fused with posterior subocular; on the right, two suboculars fused with lower postocular).

tractaspis icrolepidota

Atractaspis microlepidota, Günther

Plate XX., fig. 1

A specimen, 570 mm. long (tail 40 mm.), from Nasser, Upper Sobat, new for the Egyptian Sudan. Scales in 29 rows; ventrals, 238; subcaudals, 25. This is also the first specimen of any species of the genus *Atractaspis* hitherto known from the Sudan, though two species have been recorded from North Uganda (Wadelai).

C. M. Wenton

FIG. 42.—GOD-HELP-US ISLAND

Snakes are frequently found in open grass country and in firewood stacked for Nile steamers

The Poisonous Snakes of the Anglo-Egyptian Sudan

BY

Doctor Franz Werner

As far as we know at present, the Egyptian Sudan is inhabited by eight different species of poisonous snakes, two of which are restricted to the desert region of the North (Wady Halfa to Kordofan and Senaar), four to the tropical parts, the rest being probably found throughout the whole country, wherever the conditions of life are favourable to them.

None of these eight species is exclusively a Sudanese one; all are widely distributed over a very great part of Africa, and two of them are also found in Western Asia, one even in India.

The Sudanese poisonous snakes belong to two groups of the modern systematic division of snakes, as established by Boulenger, to the colubrine snakes and to the true vipers. Colubrine snakes and vipers

The general aspect of the poisonous colubrine snakes is that of one of the harmless species of the country. The head is covered with large symmetrically-arranged plates, and is not, or is very slightly, dilated behind, thus differing from what is generally known of the true vipers, the head of which is more or less triangular seen from above. The pupil is round; the scales of the body and tail as well as all the plates of the head are perfectly smooth; the body and tail are elongate, and neither the head nor the tail are distinctly separated from the body.

All the characters enumerated above are found equally in the non-venomous colubrine snakes; and if we wish to be quite sure of the venomous or non-venomous character of such a colubrine snake it is necessary to examine its dentition, which is characteristically different in the three large groups of colubrine snakes. We can distinguish :—

Aglyphous colubrine snakes, the teeth of which are all perfectly solid and not grooved at all. A dozen of the Sudanese species of snakes belong to this group. Varieties of colubrine snakes

Opisthoglyphous colubrine snakes (Plate XX., fig. 3). In this group the last tooth or teeth in the upper jaw are more or less enlarged, and are provided with a longitudinal groove on the anterior aspect, beginning at the base and ending before the point of the tooth. This group is likewise represented by about a dozen species.

Proteroglyphous colubrine snakes (Plate XVII., fig. 1). Here the prolonged and grooved teeth (two) are placed quite to the fore in the upper jaw, which is, in the Sudanese species, considerably reduced in length, but is always longer than broad. It is not absolutely necessary to examine the teeth in the two species of colubrine proteroglyphous snakes of the Egyptian Sudan. Both these belong to the highly poisonous genus *Naja*, widely known by the curious power snakes of this genus have of flattening their necks horizontally and raising the forepart of their bodies, thus supporting the dilated neck. Living specimens irritated in any manner—especially when prevented from escaping—very soon expand their hoods, and prepare themselves to bite, often bending the erected forepart of the body so far backward that it nearly rests on the back. The next moment the snake may protrude its head rapidly, and the energy with which this is effected is so great that a considerable part of the body may be projected with it. This gives an impression as if the snake would directly jump at the offender, but such is never really the case. How a *Naja* can be identified when killed will be seen later on, when we consider the plates covering the head. We shall see that the absence of a plate found in most of the non-venomous snakes and the configuration of the plates on the temples may be sufficient to identify this snake at a glance.

Spitting snakes

But the Najas (or at least one of the two Sudanese species) are interesting by reason of another curious habit. It has been for a long time a matter of discussion as to whether the often described "spitting" of the snakes belonging to the genus *Naja* is a fact or only a product of the phantasy of some travellers. Very rarely, the spitting seems to have been observed in the Indian *Naja tripudians*,[1] one of the best known snakes of our globe; and I do not remember that this habit has been recorded in connection with the other Asiatic species. Such reports as regards African Najas are, however, rather frequent, especially from West and South Africa, concerning in Western Africa probably *Naja nigricollis*, in South Africa the indigenous *Naja flava*, or the same species.

It is not so very long ago that the spitting of the so-called "spitting snakes" ("cobras cuspideiras" of the Portuguese colonists) was accepted as a fact; and this may be due to the experiments of Dr. Maclaud, Prof. Barboza du Bacage and others in the last years of the past century.

Had I ever doubted this fact I would have changed my opinion after seeing a full-grown specimen of *Naja nigricollis*, the Black-necked Naja, that had just been brought to me in Gondokoro, spitting directly at my friend and companion, Dr. Sassi, after some chewing movements of the jaws.

Saliva of spitting snakes

Fortunately the saliva thus ejected causes no fatal effect when impinging on the unwounded skin; and even the mucous membranes and more delicate parts, such as more especially the cornea and conjunctiva, etc., of the eye, often reached by the saliva, are, though liable to severe inflammation, in no real danger if the saliva is washed away at once.

All Najas of the Sudan have, owing to the faculty of dilating the neck, a faculty facilitated by the presence of narrower and more numerous scales, at least two or four scales more in a transverse row at the neck than on the middle of the body; whilst in the other snakes of the Sudan the number of scales from one side of the enlarged ventral plates to the other across the back is greatest at the thickest—usually the middle—part of the body.

Naja hajæ, the supposed snake of Cleopatra, and no doubt the snake which Moses used in carrying out his tricks before the Pharaoh—tricks that are still executed in the same manner by the Egyptian snake-charmers of to-day—is by far the longest, but not the most bulky, colubrine snake of the Sudan. I got a specimen two metres long at Khor Attar, some miles south of Taufikia, at the eastern bank of the White Nile; and no doubt there exist still longer ones, though they never attain such a length as the Indian *Naja bungarus* or Hamadryad, the longest of all poisonous snakes, which is known to reach more than four metres of total length.

Vipers

Of the six true vipers of the Sudan two are common to Egypt and the Northern Sudan, the others being only found south of Khartoum.

Three of them, among which is the common "green viper" of the Sobat, differ somewhat from the others, for the head is covered above with large, symmetrical, smooth plates; while the others have the head-scales small, numerous, strongly keeled, and strong longitudinal keels are also to be observed on the scales of the body (always with the exception of the large plates on the belly and the lower side of the tail, which are always

[1] A single record is known to me: Jones Goring in *Journal of Bombay Society*, Vol. XIII., 1900, page 376.

smooth). All true vipers possess a very short upper jaw (Plate XIX., *c*), which is not firmly united with the adjacent bones of the head, but movable in a vertical plane and provided with two long fang-like teeth curved somewhat backwards; further teeth (reserve teeth) just behind them may also be present and take their place when they have fallen out.

The fangs lie on the palate, with the sharp points directed backwards; they are covered nearly to the tips with a sheath, which is retracted when the snake opens its mouth to bite. In this case the mouth is widely opened, the upper jaws turn forward and their fangs become erected, the tips pointing even somewhat forward; all this takes place at the very moment when the snake throws its head forward against its prey or offender, and the fangs can then enter the flesh of the victim with considerable force. They are, if possible, withdrawn immediately afterwards. If the victim should make a violent movement in a contrary direction, a fang may be lost and remain in the flesh; in this case, the reserve fang may take its place, when it is the normal time for the fang to be changed.

Apart from their attachment to a movable, short upper jaw, the fangs are themselves different from those of the Najas, by their not being grooved at the front margin, but entirely channelled longitudinally by a poison-canal, an opening existing only at the base and just above the point of the tooth.

The poison-gland is in both the poisonous colubrine snakes and the true vipers a modified part of the salivary gland of the upper jaw (supramaxillary gland), and is connected by a narrow duct to the base of the poison-fang. The poison runs down to the tip of the fang along the groove in the Najas, and in the poison-canal in the true vipers. Poison-glands

The constriction of the poison-gland, whereby the poison is expressed, is caused by the pressure of a ligamentous jugal band on the gland; this band is supported more or less in its action by the muscles of the upper jaw. In the genus *Causus* the poison-gland is very large and prolonged backwards beyond the insertion of the lower jaw (Plate XIX., *c*); here the muscles alone are effective in pressing out the poison. Further information on the poisonous apparatus of the snakes is to be found in the following excellent publication:—

Stejneger, L.: "The Poisonous Snakes of North America." In *Report of the United States National Museum*. Washington, 1893.

The following descriptions are chiefly taken from G. A. Boulenger's standard work, *Catalogue of Snakes in the British Museum*, but are a little modified in some cases, as Sudanese specimens differ (especially in colour) from the descriptions in this book. I have given only the most essential indications as regards the literature and references to good figures, but hope that this paper will be useful for the recognition of the poisonous snakes of the Sudan.

Descriptions of the Sudanese Venomous Snakes[1]

I. *Proteroglyphous Colubrine Snakes*

Anterior teeth of the upper jaw enlarged, with a longitudinal groove along the front surface, conveying the poison from the duct of the poison-gland to just above the point of the tooth. Upper jaw more or less elongate, not erectile. Loreal plate of the head-shields constantly missing in both Sudanese species.

Genus: *Naja*, Laurenti

A pair of large grooved poison-fangs, followed after an interspace by one to three small, faintly-grooved teeth, situated near the posterior end of the upper jaw (Plate XVII., fig. 1, *c*).

[1] For explanation of scientific terms, *see* Appendix, *page* 185.

Anterior teeth of the lower jaw longest. Head not or but slightly distinct from the neck; eye moderate or rather large, with round pupil. Scales smooth, in 15-25 longitudinal rows (or more on the neck). Body cylindrical, rather elongate; tail moderate. Africa, West and South Asia.

Naja hajæ, Linnæus (Plate XVII., fig. 1)

G. A. Boulenger, *Catalogue of the Snakes in the British Museum* (Natural History), Vol. III., 1896, page 374.

J. Anderson, "Zoology of Egypt, I. Reptiles and Batrachians," 1898, page 312, Plate XLIV.

F. Werner, "Ergebnisse der mit Subvention aus der Erbschaft Treitl unternommenen Zoologischen Forschungsreise, Dr. F. Werner's nach dem ägyptischen Sudan und Nord Uganda." XII., Die Reptilien und Amphibien. *Sitz. Ber. Akad. Wiss. Wien.* Bd. CXVI., December 1st, 1907.

Sixth (rarely seventh) of the seven (rarely eight) upper labials largest and deepest, in contact with lower postocular. Rostral as deep as broad or slightly broader than deep, the portion visible from above measuring one half to two thirds its distance from the frontal; one or several more or less enlarged occipital scales behind the parietals; one preocular, not in contact with the internasal; two or three postoculars, two or three suboculars, separating the eye from the labials; temporals 1 + 2 or 3; 21-23 scales across the neck, 19-21 across the middle of the body. Ventrals, 191-210; subcaudals, 53-67. Yellowish or olive to dark brown or blackish above, uniform or with darker or lighter spots; lower parts yellowish, with a brown or black band on the neck, or dark brown to blackish; head sometimes blackish. Both the specimens from the Sudan which I have examined are uniformly dark brown.

This highly poisonous snake attains a length of 2 metres (tail 280 mm.). It is of a very irascible and aggressive temperament, feeds on small mammals (mice or rats), birds, and frogs, and has a very wide distribution, being known all over Northern Africa, North of the Sahara, in Southern Palestine, South Arabia and East Africa to Zululand (cf. *G. A. Boulenger*, m., *Ann. Natal Gov. Mus.*, Vol. I., Part 3, May, 1908, p. 230). In the Sudan it is known from two localities not far from each other, viz. from the lower Sobat (Doleib Hill) and the White Nile, between the Sobat and Bahr-El-Zeraf (Khor Attar); the first specimen is preserved in the Khartoum Museum (Gordon College), the other in the Vienna Museum. Nothing is known about its spitting faculty.

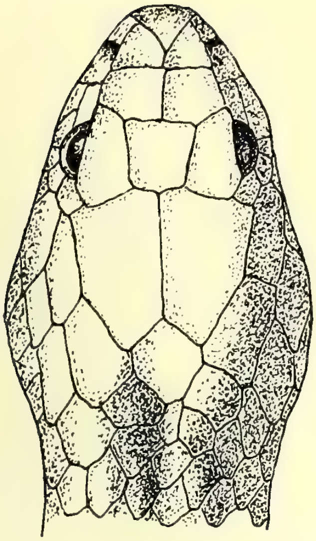
Naja nigricollis, Reinhardt

Black-necked spitting-snake

Black-necked spitting-snake (Plate XVIII., fig. 2)

Boulenger, p. 378; Anderson, p. 322, Plate XLV.; Werner, p. 1883.

Rostral once-and-a-half as broad as deep, the portion visible from above measuring one third to half its distance from the frontal; no enlarged occipital; two (rarely one) præ- and three postoculars; temporals, 2 or 3 + 4 or 5; six (rarely seven) upper labials, third (or third and fourth) deepest and entering the eye, last longest; 21 to 29 scales across the neck, 17 to 25 across the middle of the body; ventrals, 183 to 228; subcaudals, 55 to 68. Coloration, very variable; the Sudan and North Uganda specimens stand near to the variety called *mossambica* by Peters (*Monatsberichte der Berliner Akademie der Wissenschaften*, 1854, p. 625); they are olive grey above, but the scales are not black-edged; neither is the skin between the scales distinctly black. The throat and upper labials are dark, the lower surface of neck with dark and yellow transverse bands; the remainder of the lower surface yellowish or greenish olive; speckled or ventrals margined posteriorly with a lighter hue.



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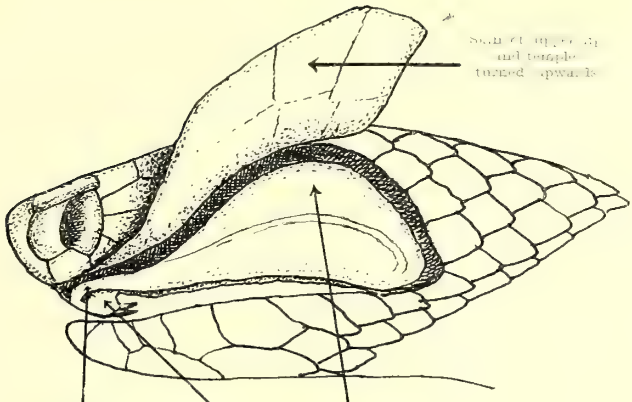

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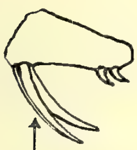

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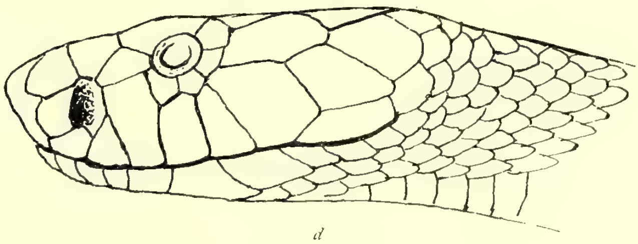
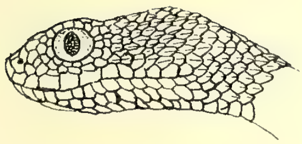


d

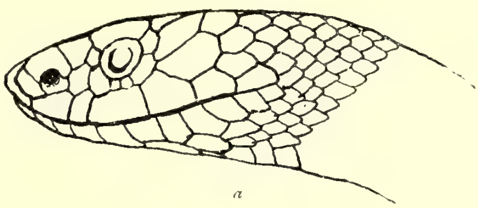
1. Naja Hajæ
(Proteroglyphous Colubrine type)
Adult length = (approx.) 2 metres



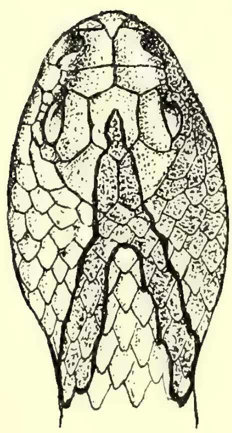
a

b

2. Echis carinatus
Adult length = (approx.) 720 mm.



a



b

3. Causus rhombeatus
Adult length = (approx.) 700 mm.

This species likewise attains a length of two metres (tail, 300 mm.), but no specimen of such dimensions has been found hitherto in the Egyptian Sudan. It possesses the same ferocious habits as the preceding, and is, undoubtedly, the snake which deserves first rank as a spitting snake, as the majority of the observations about this curious habit are referred to it.

The distribution of this snake is still more extensive than that of the preceding one, for we have records of it from nearly the whole of Tropical Africa—from Senegambia to the Sudan, and even to Upper Egypt, and from Angola to the Transvaal. In the Nile valley it is known from Assuan (Anderson, Werner) to Gondokoro (Werner), has been recorded from Khartoum by L. G. Anderson, and collected at the Sobat, near Taufikia, by Dr. Wenyon.

A third species of Naja, *N. melanoleuca*, Hallowell, has been found in Uganda by Mr. Baxter, and may eventually be met with in the Sudan. It agrees with *N. hajæ* in having the sixth upper labial largest and in contact with the lower postocular, but differs in having the third and fourth upper labial entering the eye, and the rostral considerably broader than deep. Sides of head yellowish or whitish; some or all of the labials with posterior black edge; head and body black above, uniform or (in the young) with white dots or edges to the dorsal scales; the white mostly disposed in cross-bars; anterior ventral region with yellowish cross-bars alternating with black ones. Total length (according to Boulenger), 2·400 metres; tail, 700 mm. Rather common in West Africa from the Niger to the Gaboon, especially in the Cameroons; apparently rare in East Africa.

II. *True Vipers*

True Vipers

Upper jaw very short, erectile and supporting a pair of very large poison-fangs without external longitudinal groove, but with inner canal; no teeth on the upper jaw behind these fangs.

Genus: *Causus*, Wagler

Head covered with large symmetrical shields, as is normally the case with the Colubrine snakes; teeth in the lower jaw well developed; eye moderate, with round pupil, separated from the eye by subocular scales; loreal shields present. Body, cylindrical, scales smooth or keeled, oblique on the sides, min. 15–22 rows; ventrals rounded; tail short, subcaudals in two rows or single. Poison-gland very elongate, situated at the side of neck, between the skin and the body-muscles (*see* Plate XIX, *c*).

Tropical and South Africa.

Causus rhombeatus, Lichtenstein (Plate XVII., fig. 3)

Boulenger, l.c., p. 467

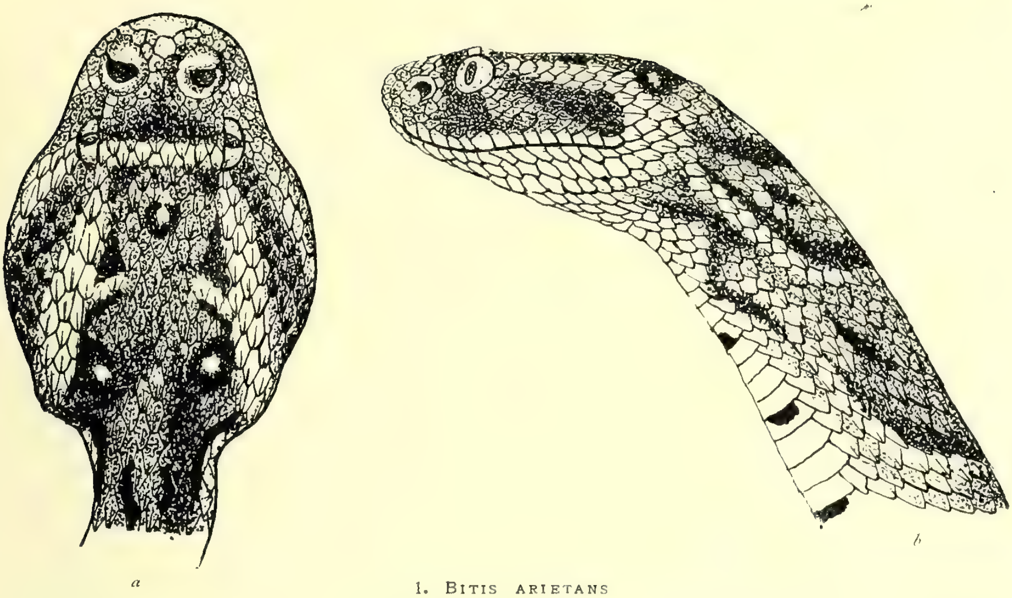
(Figured in Schlegel, *Essai sur la Physiognomie des Serpens*, II., 1837, p. 483, Plate XVII., figs. 12 and 13)

Snout obtuse, not turned up at the end. Scales in 17-21 rows, dorsals more or less distinctly keeled; ventrals 120–155; subcaudals 15–29, all or greater part in pairs. Coloration olive or pale brown above, rarely uniform, usually with a dorsal series of large rhomboidal or V-shaped dark brown spots, in many edged with black, usually a large dark V-shaped marking on the back of the head, the point of the frontal, and an oblique dark streak behind the eye (missing in the only known specimen from the Sudan); labials usually dark edged (not in the Sudan specimen); lower parts yellowish-white, uniform, or the shields edged with black.

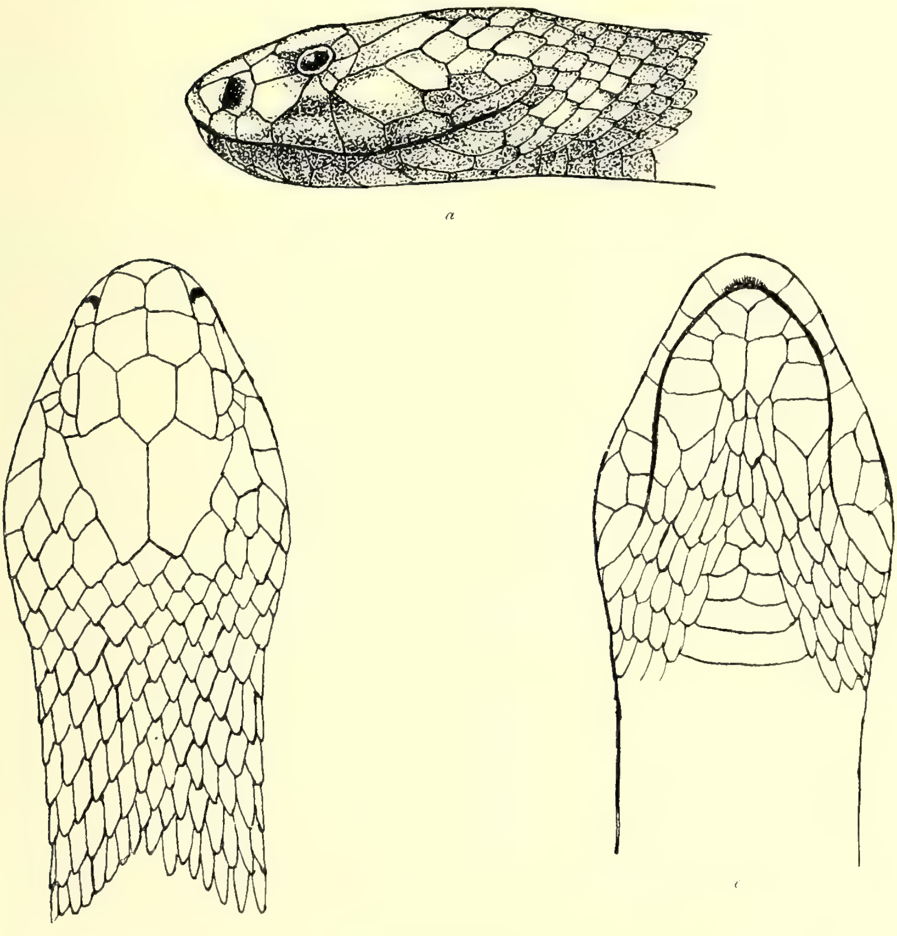
Total length, 700 mm.; tail, 75 mm.

Tropical and South Africa.

PLATE XVII



1. Bitis arietans
Head from above and from side
Adult length = (approx.) 1350 mm.



2. Naja nigricollis
Head, seen from side, from above and below
Adult length = (approx.) 2·400 mm.

This widely-distributed viper has been found in the Egyptian Sudan by Dr. M. Wenyon. It seems to be much less common here than in the other parts of Tropical Africa, its place being taken by the following species. It feeds especially on frogs and toads.

Causus resimus, Peters

Green Viper

Green Viper

Boulenger, l.c., p. 468; Werner, l.c., p. 1884

Figured and first described by Peters, in *Monatsber. Akad. Wiss.*, Berlin, 1862, p. 277, Plate XIX.

Snout more prominent than in the preceding species, often more or less distinctly turned up at the end. Scales smooth or more or less distinctly keeled (strongly in adult specimens from the Sudan, the keels not reaching the point of the scales) in 19 to 22 rows; ventrals, 134–155; subcaudals, 17–27 pairs. Greyish or bluish-green above, with a dorsal series of narrow black, curved or chevron-shaped cross-bars pointing backwards; oblique narrow black bars on the sides, often reduced to mere traces or to black margins on some of the scales. Black margins of three and four upper labials, a black line from behind the eye to the posterior margin of the fifth upper labial, constant in Sudanese specimens; the Λ-shaped spot on the back of the head with the point on the posterior point of the frontal shield; lower surfaces yellowish-white, uniform or shields margined posteriorly with black.

Total length, 670 mm.; tail, 70 mm.

Common on the banks of the Sobat River, where it is known by the missionaries of Doleib Hill as the "Green Viper." Dr. Wenyon found it at Taufikia, and I myself found it at Khor Attar (White Nile). Nothing seems to be known about its habits.

Genus: *Atractaspis*, Smith

Poison-fangs enormously developed; lower jaw with very few and small teeth; head, small, not distinct from the neck, covered with large symmetrical shields as in the preceding genus; no loreal; eye, minute, with round pupil, in contact with upper labials. Body, cylindrical, rather elongate; scales smooth, in 17–37 rows; ventrals rounded. Tail short, subcaudal, single or in two rows.

Tropical and South Africa; South Arabia.

Burrowing snakes, of small size and mostly uniform dark coloration. Most of the numerous (about twenty) species are rare, and represented in collections by a single or few specimens. They are oviparous.

Atractaspis microlepidota, Günther

Plate XX., fig. 1

Günther, in *Annals and Magazine of Natural History* (3) XVIII., 1866, p. 29, Plate VII., fig. 3; and (6) I., 1888, p. 332

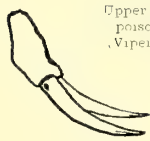
Boulenger, *Ann. Mus., Genova,* (2) XV., 1895, p. 15; and *Cat. Snakes,* III., 1896, p. 517

Peters, *Monatsber. Akad. Wiss.,* Berlin, 1866, p. 890; and in Decken's "Reise O. Afr.," III., p. 17, Plate I., fig. 3 (1869)

As there are still several species of this genus which one may expect to find in the Sudan, I reproduce here the full description, given by Boulenger, to avoid confusion with others:—

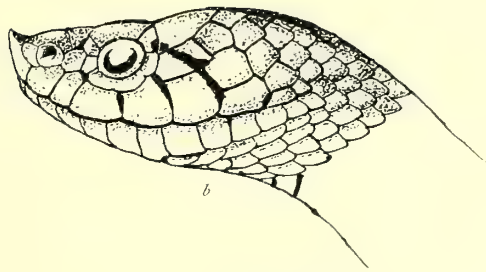
"Snout very short, prominent, subcuneiform. Portion of rostral, visible from above, nearly as long as its distance from the frontal; suture between the inter-nasal as long as

PLATE XIX



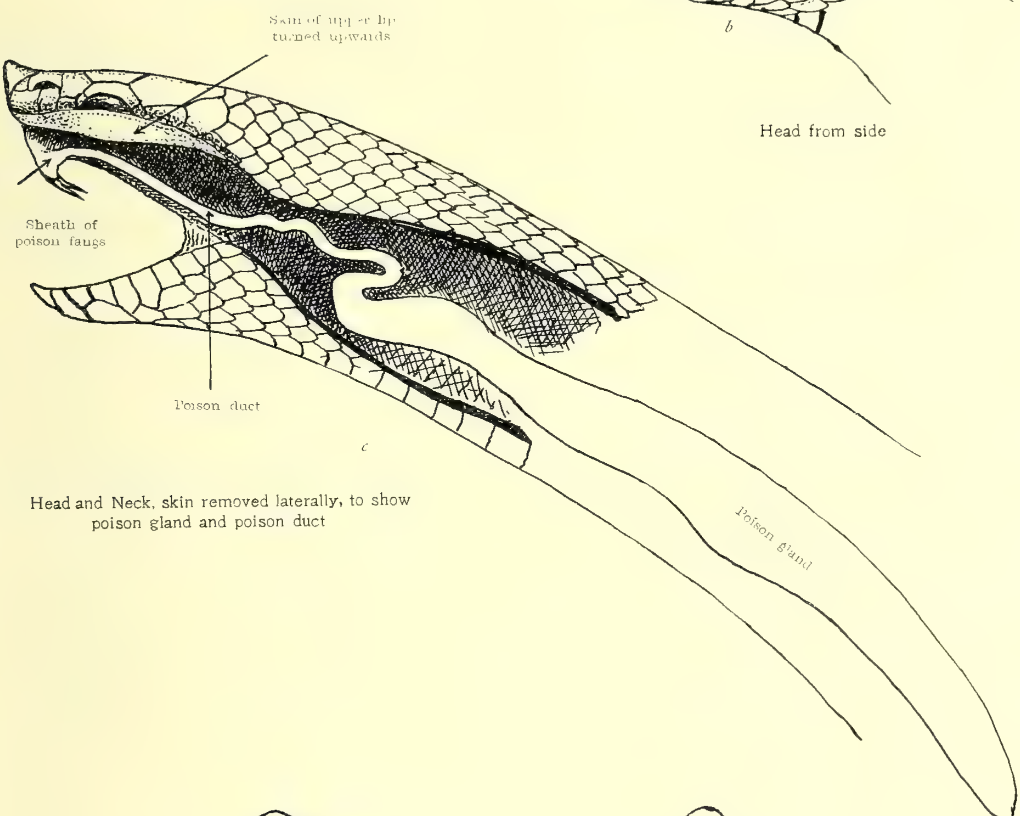
Upper jaw with poison fangs (Viperine type)

a



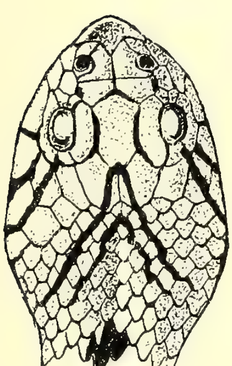
b

Head from side



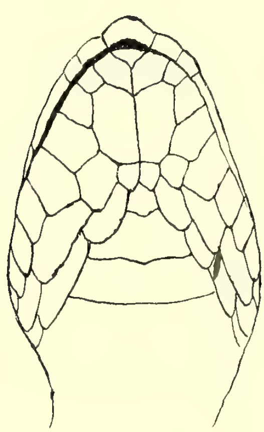
c

Head and Neck, skin removed laterally, to show poison gland and poison duct



d

Head from above



e

Head from below

Causus resimus

Adult length = (approx.) 670 mm.

that between the præ-frontals; frontal a little longer than broad, much longer than its distance from the end of the snout, longer than the parietals, one præ- and one post-ocular; temporals small, 2 by 3 or 4; six upper labials, third and fourth entering the eye and largest; first lower labial in contact with its fellow behind the symphysial; three lower labials in contact with the chin-shields. Scales in 29–37 rows; ventrals 212–245; anal entire; subcaudals 26–37, single. Uniform dark brown.

"Total length, 540 mm.; tail, 45 mm.

"East and Central Africa."

The specimen collected by Dr. C. M. Wenyon at Nasser (Sobat River) is somewhat longer (570 mm., tail 40 mm.) and really black. No other specimen is known from the Sudan.

Two species of *Atractaspis* from Wadelai have been sent to the British Museum by Emin Pasha. As they may be found also in the Sudan, I give here the distinctive characters:—

I. Anal divided; subcaudals all or greater part divided. (Scales in 25–27 rows; ventrals 200–257) . . . *A. irregularis*, Reinhardt.

II. Anal entire; subcaudals, all or greater part entire.

(1) Postocular in contact with a large temporal; third lower labial very large; scales in 19–21 rows; ventrals, 251–300. . . . *A. aterrima*, Günther.

(2) Temporals small, 2 by 3 or 4; fourth or fifth lower labial largest; scales in 29–37 rows; ventrals, 212–245 . . . *A. microlepidota*, Günther.

Genus: *Bitis*, Gray

Head very distinct from neck, covered with small imbricate scales; eye moderate or very small, with vertical pupil, separated from the labials by small scales; nostrils directed upwards or upwards and outwards, pierced in a single or divided nasal, with a deep pit or pocket above, closed by a valvular, crescentic supra-nasal. Scales keeled, in 22–41 rows; ventrals rounded; tail very short; subcaudals in two rows.

Africa, South Arabia.

Bitis arietans, Merrem

Plate XVIII., fig. 1

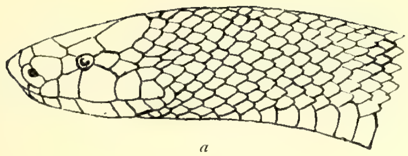
Boulenger, *Cat. Snakes*, III., 1896, p. 494; Werner, l.c., p. 1885. (Figured in Schlegel, "Essai Physiognom. Serp.," II., Plate XXI., figs. 1–3 [1837]; Duméril and Bibron, "Erpétologie Générale," VII., Plate LXXIX., fig. 1 [1854]; Jan, "Iconogr. Gen. Ophid.," 45, Plate VI., figs. 3, 4 [1874].)

Puff-Adder "Puff-Adder" of the Dutch Colonists of South Africa. Nostrils directed upwards. No horns on the snout or above the eyes; one or two series of scales between the rostral and the nasal; scales in 29–41 rows, strongly keeled; outer row smooth or feebly keeled; ventrals, 131–145; subcaudals, 16–34 pairs.

Yellowish, pale brown or orange above, marked with regular chevron-shaped dark brown or black bars pointing backwards, or black with yellow or orange markings; a large dark blotch covering the crown separated by a smaller inter-orbital blotch by a transverse yellow line; an oblique dark band below and another behind the eye; yellowish-white below, uniform or with small dark spots.

This very thick and bulky viper is the largest species of viper in the Sudan; the longest specimen in the British Museum is 1350 mm. (tail 160 mm.), but no doubt it grows still larger. It is known in the greater part of Africa, viz. from Southern Morocco, Kordofan and

PLATE XX



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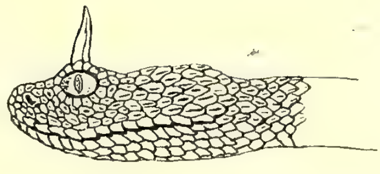

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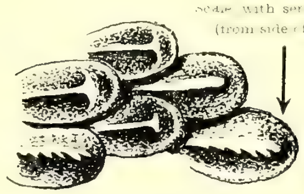

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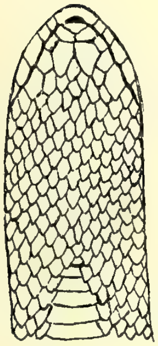

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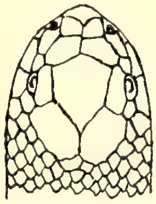

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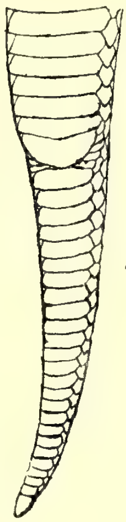
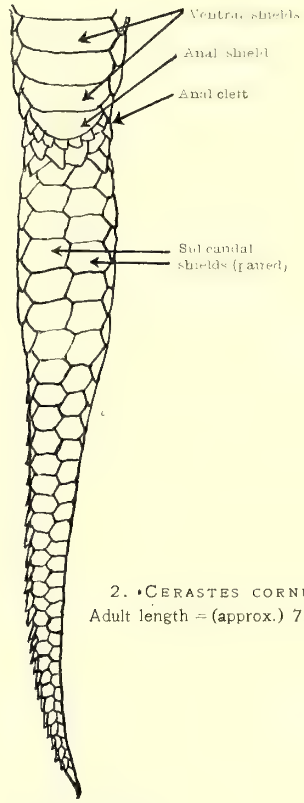


d

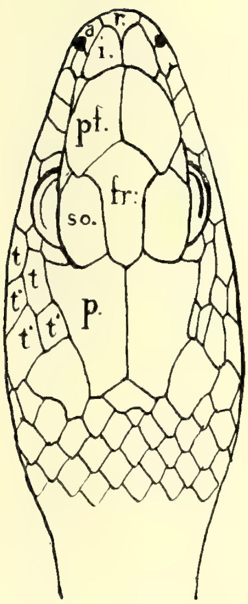
1. Atractaspis microlepidota
Adult length = (approx.) 540 mm.

(*a*) Head from side
(*b*) from above
(*c*) from below
(*d*) tail from below
(subcaudal shields single)



Tail from below

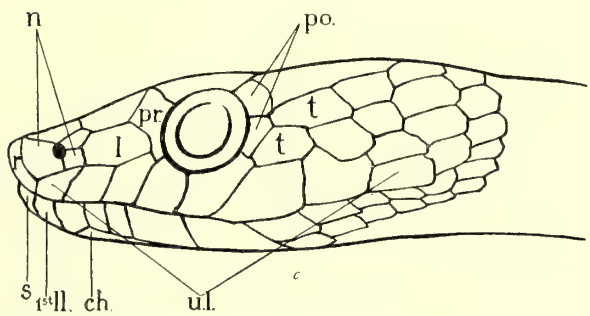
2. Cerastes cornutus
Adult length = (approx.) 720 mm.



b

a

Upper Jaw



c

3. Psammophis sibilans Opisthoglyphous colubrine type)
Adult length = (approx.) 1500 mm.

a. = anterior nasal
r = rostral
i. = inter-nasals
pf. = præ frontals
fr = median frontal
so = supra oculars
p = parietals
t. = temporal scales
u l = upper labials
n = nasal
l = loreal
pr = præ-ocular
po = post-oculars
t = anterior temporals
s = symphysial
1st ll = first lower labial
ch = chin shield (of anterior pair)

Erythrea to the Cape of Good Hope and also from South Arabia; but as it is a snake of open plains and savannahs it has not been recorded from countries with thick forest, such as the Cameroons.

Boettger believes this snake to be an aquatic one, on account of its nostrils being turned directly upwards, and its feeding, especially, on frogs. This is certainly not the case in the Sudan and near Gondokoro, where it frequents the savannahs and even the hills far from any water and, accordingly, from frogs, which are more limited to the water (at least, in the dry season) than in Europe.

We know several localities for this viper in the Sudan, as already enumerated in my publication on the Sudan reptiles. Hartmann found it in the Bêjuda-Steppe, Ruppell, in Kordofan, Marno, at the Tura-El-Chadra and the Dabbed-Hanakhi; a specimen from the Sobat is in the Gordon College Museum, and another one, found by myself at Goz-Abu-Guma, in the Vienna Museum. No other of the eight species of *Bitis* probably occurs in the Sudan.

Genus: *Cerastes,* Wagler

Head, very distinct from neck, covered with small juxtaposed or feebly imbricate scales; eye, moderate or small, with vertical pupil, separated from the labials by small scales; nostril directed upwards and outwards. Body, cylindrical; scales keeled, in 23–35 rows; dorsal scales forming straight longitudinal series, with club- or anchor-shaped keels, not extending to the extremity of the scale; lateral scales smaller, oblique, pointing downwards, with serrated keels; ventrals with an obtuse keel on each side. Tail, short; subcaudals in two rows.

North Africa, Arabia, Palestine.

Cerastes cornutus, Linnæus

Plate XX., fig. 2

Horned Viper

Horned Viper

Boulenger, *Cat. Snakes,* III., p. 502

Anderson, "Zool. Egypt., Rept.," p. 330, Plate XLVIII

Fifteen to twenty-one scales across the front, from eye to eye; a large, erect, ribbed, horn-like scale, often present above the eye; 14–18 scales round the eye; 4–5 series of scales between the eye and the labials; nostril in a single small shield, separated from its fellow by 6–8 longitudinal series of scales, from the rostral by two or three (rarely one); 12–15 upper labials; scales in 27–35 rows. Ventral, 130–165, with feeble lateral keel; subcaudals, 25–42; the posterior usually more or less distinctly keeled. Coloration, pale yellowish-brown above, uniform or with 4–6 regular series of round brown spots, the two middle ones sometimes confluent, forming cross-bars; a more or less distinct oblique dark streak behind the eye; lower parts, white; end of tail rarely black.

Total length, 720 mm.; tail, 90 mm.

Northern border of the Sahara, Egypt, Nubia, Arabia, Southern Palestine.

The horned viper is restricted to the sandy parts of the Northern Sudan, and has not been found south of Senaar (Bruce); Anderson got it at Wady Halfa and Suakin; Hartmann in the Bêjuda; specimens from Dongola (without horns) are in the Gordon College Museum.

This, like the following species, is admirably adapted for life in sandy, desert localities. The serrated keels of lateral scales acting as sand ploughs, the snake can, by curious strong movements of its body-muscles, rapidly disappear before the eyes of the spectator by covering itself with sand and sinking vertically down in it without moving its body as a whole. It has its holes mostly between the roots of low desert plants; feeds especially on small mammals (mice), and is, like probably all true vipers, capable of being tamed, so far as to take food from its master's hand.

The other species of Cerastes (*C. vipera*, L.) does not enter the Sudan, being restricted to North Africa proper.

Genus: *Echis*, Merrem

Head very distinct from neck, covered with small imbricate scales; eye moderate, with vertical pupil, separated from the labials by small scales; nostril directed upwards and outwards. Body cylindrical; scales keeled, in 27–37 rows; dorsals forming straight longitudinal series; lateral scales smaller, oblique, pointing downwards, with serrated keels; ventrals rounded. Tail short; subcaudals single.

Africa, north of the Equator; Southern Asia.

Echis carinatus, Schneider

Plate XVII., fig. 2

Boulenger, *Cat. Snakes*, III., p. 505

Anderson, "Zool. Egypt.," I., p. 336, Plate XLIX.

Head covered with small, more or less strongly keeled, scales; a narrow supra-ocular sometimes present; two (rarely three or one) series of scales between the eye and the labials; anterior nasal shield in contact with the rostral; 10–12 upper labials; scales in 27–37 rows. Ventrals, 132–192; subcaudals, 21–48. Pale buff, greyish, reddish, or brown above, with one or three series of whitish, dark-edged spots; a zigzag dark and light band may run along each side; a cruciform or arrow or **Y**-shaped whitish marking often present on the head; lower parts whitish, uniform, or with brown dots or with small round black spots.

Total length, 720 mm.; tail, 70 mm.

Desert or sandy districts of Africa, north of the Equator; Southern Asia, from Transcaspia and Arabia to India.

This small and widely distributed viper is known in the Sudan only from the northern parts; from Suakin and Durrur by J. Anderson; from Khartoum, Dongola and Kordofan (Mazrūb) by A. L. Butler. But as it ranges southwards to Togo and Somaliland, there is no doubt that it will be found also in the Upper Nile valley. It is much feared everywhere, and known as "Efa" in North Africa and as "Phoorsa" in North India. It feeds principally on small mammals and birds. The second species of this genus, *E. coloratus*, Günther, is restricted to Palestine, Arabia and the Red Sea Coast of Egypt, and may be found also in the Sudan, though I think that both species are mutually exclusive.

Appendix

The snakes called "Opisthoglyphous," having the last teeth of the upper jaw more or less enlarged and longitudinally grooved on the front surface, are also poisonous in different degrees, according to genus. But only a few species reach such dimensions as to be able to bite a man successfully—the poison-fangs being so far back in the mouth that only small parts of the human body like a finger can come within their reach. Moreover, the poison of most of them does not act perceptibly on man. Practically only the genus *Psammophis*, and, among its four species, only *P. sibilans*, L. (Plate XX., fig. 3), would be considered as venomous. In the Upper Nile Valley this snake reaches a length of about five feet, and may be easily identified on account of its large eyes with round pupils, the very elongate loreal, and the prominent supra-ocular. As it is by no means aggressive, but takes rapidly to its refuge at the approach of man (though fiercely defending itself by biting when caught), I do not believe that it is to be feared in any way. A figure of its head is given on Plate XX., fig. 3, *c*. Coloration, brown above, with a more or less distinctly yellow line in the middle of the back; lower surface, white anteriorly to yellow in the posterior part.

The Scaling of a Snake's Head and Body

The upper lip of all Sudanese snakes is bordered by a row of more or less enlarged plates, the upper labials (u.l.); the middle one on the end of the snout, and emarginated below, to allow the tongue to be protruded from the mouth, is called the rostral (r.). At each side of the head we find a nasal (n.) shield, perforated by the nostril and often divided vertically (the hind part, in addition, horizontally in *Psammophis sibilans*). This shield is followed backwards by a loreal (l.), elongate in *Psammophis*, missing in *Naja* and *Atractaspis*, indistinguishable in the snakes with many small head-scales, like *Bitis*, *Cerastes* and *Echis*. Behind the loreal, and between this and the eye, we find the præ-ocular (one or two, rarely more); behind the eye, the post-oculars (two or three, rarely one). The eye may be separated from the upper labials by suboculars (see *Naja hajæ*, *Causus*), even occurring in several rows, as in *Bitis*, *Cerastes*, *Echis*, or some of the upper labials may enter the eye (*Psammophis*, *Atractaspis*, *Naja nigricollis*). The temples behind the post-oculars are covered with temporal scales ($t\,t^1$) in several rather vertical rows, only the first two rows being, however, counted in the descriptions.

The upper surface of the head behind the rostral is covered by nine large plates (four pairs and one unpaired), in *Psammophis*, *Naja*, *Causus* and *Atractaspis*, by small keeled ones in *Bitis*, *Cerastes* and *Echis*. The plates are called as follows, from snout to back of head: inter-nasals (between nasals) (i.), præ-frontals (pf.), supra-oculars (so.); between these the median frontal (fr.), behind them the parietals (p.). Lower surface of head: round the lower lip = lower labials; the middle one below the rostral = symphysial; behind the symphysial = the chin-shields, one or two pairs; behind them the gular scales, followed by the broad ventrals (fig. 2), which cover the whole lower surface of the body; the last ventral covering the vent, longitudinally divided or entire, is the anal. The tail is covered below by the subcaudals (single like the ventrals in *Atractaspis* and *Echis*, paired in the others). The scales of the upper parts of body and tail are arranged mostly in longitudinal rows. They are counted on the thickest part of the body obliquely across the back from one side of the enlarged ventrals to the other; they are nearly always in odd numbers in the Sudanese species.

An Account of some Helminthes contained in Dr. C. M. Wenyon's Collection from the Sudan

BY

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The collection of parasitic worms made by Dr. Wenyon during his stay in the southern parts of the Sudan was handed to me in most excellently preserved condition for further investigation and description. The number of individual species obtained by him is considerable. Some of them are known to science only in briefest outline; others are new, and in some instances present highly novel characteristics. An account of the Nematodes and Trematodes alone is given in this paper, which deals with them from the systematic standpoint rather than from that of species anatomy, to which the material so admirably lends itself. These restrictions have been imposed by the limited time available for the examination of the material and the amount of helminthological literature involved in the identification of forms but distantly related to one another.

The hosts of the ten varieties of Nematoda were Mule, Bat, Guinea fowl, Snake, Toad, and Garmot fish. The Trematoda were of four kinds, and were obtained from Waterbuck, Sheep and Marabou Stork. The Cestodes, contained in sixteen tubes, remain unexamined.

Preparatory Methods

Methods of preservation

The great bulk of the helminthological material from abroad usually reaches England in a very poor state of preservation, owing to the use, by collectors, of methods that are quite inapplicable to these particular parasites, however excellent they may have proved themselves for general histological purposes.

It may not be out of place, therefore, to detail briefly the methods used, and the further treatment adopted, in the investigation of the helminthes that form the subject of this paper.

The Nematoda and Trematoda react in such radically different ways to various fixing reagents that those adopted for one group are often quite unsuited to the other.

Nematoda.—Formalin, on account of its general use and handiness, is a very commonly used preservative. It should, however, never be used for roundworms, unless in the absence of other reagents. It over-distends, and in weak solution, badly macerates, the tissues. In 10 per cent. solution specimens sometimes keep well, but it frequently happens that, during the process of fixation, the specimens coil considerably, and often part of the viscera is extruded by rupture of the integument during spasmodic contraction. The lack of transparency of formalin-preserved specimens renders the observation of details of structure and internal topography difficult, but the required details must be searched for in this fluid once the animals are fixed in it, as transference later to glycerin, no matter how gradual the process, leads to irretrievable shrinkage and distortion. For the same reason Kaiserling's fluid should never be used. The preservation of colour in the Nematoda is of practically no importance. Mercurial solutions destroy the translucency and form deposits within the tissues. The preservative reagent, *par excellence*, for the Nematodes is alcohol, but its use must be governed by certain rules, otherwise the inevitable contraction and shrinkage will occur.

Action of alcohol

Looss has found, by experiment, that if living Nematodes be dropped into boiling 70 per cent. alcohol they will die extended and without local distortions, and that such specimens may thereafter be slowly infiltrated and rendered transparent by glycerin. For field work in the Tropics, and to obtain most satisfactory results, it is only necessary to be provided with a supply of spirit, a large test-tube, a brass spirit lamp, and a small enamel pan 3 in. by 3 in. The pan should be of just such a size as will contain the lamp within it and thus reduce the space to a minimum. The pure spirit suffices for the lamp, and when diluted to the strength of 70 per cent. alcohol it serves as reagent. The specimens when collected are shaken up vigorously in half a test-tube of 1 per cent. saline solution, in order properly to cleanse the mouth parts and genital papillæ of foreign matter, and then poured out into a flat vessel—petrie dish or an ordinary plate. A quantity of the 70 per cent. alcohol solution is then poured into the enamel pan, filling it to the depth of about half-an-inch. It is then heated over the spirit flame until it just commences to boil. Thereon the pan is quickly raised from the flame, and the specimens are rapidly transferred one by one from the saline solution. They should immediately straighten themselves out and die in an extended condition. When all the specimens have been killed in this way they should then be transferred to small tubes of cold 70 per cent. alcohol, in which they will remain without shrinking or becoming brittle for a long time.

For examination the specimens must be further treated in order to render them transparent. If small, or if external anatomy only is required in larger worms, they should be cleared in glycerin. The worms are taken from the 70 per cent. storage alcohol into a solution of 70 per cent. alcohol to which has been added 5 per cent. of pure glycerin. The whole is then allowed to evaporate slowly, say in a temperature of about 60° C. The alcohol is gradually driven off, leaving the glycerin to become more and more concentrated; the process not being completed until there remains only a small quantity of very viscid glycerin containing the worms. The specimens then may be examined immediately, stored in pure glycerin, or mounted in glycerin-jelly as permanent preparations. Should a more rapid examination be necessary than is allowed by the above method, the specimens, after fixation in boiling 70 per cent. alcohol, may be transferred for thirty minutes to 96 per cent. or absolute alcohol, and then cleared in "white" creosote. This renders the specimens exceedingly transparent, so that even the histological details of the different internal organs may all be observed by various focussing. It is well suited for the study of the relationships of the internal structures of the larger and more opaque forms, and has an additional merit—that in the course of twenty-four hours the creosote will, by slow endosmosis, restore to normal contour any irregularities that may have been caused by the spirit. The cleared specimens should be examined *in creosote* and then returned for storage to 70 per cent. alcohol, as they do not mount satisfactorily in Canada balsam, and become deeply stained if they are left for any length of time in creosote, though in other respects they are uninjured and still retain their natural softness and contour. The 70 per cent. alcohol is much the best stock solution for museum purposes, for the specimens are then available at any time for investigation or reference by either of the above processes, and they are not rendered brittle, as by spirit, in course of time.

Rapid method of examination

Trematoda

Trematoda.—The only apparatus required for the Trematoda is a supply of test-tubes and collecting bottles, and the following reagents: 1 per cent. saline solution, saturated corrosive sublimate, 10 per cent. formalin, 70 per cent. alcohol. The saline solution is used as a cleansing reagent; the specimens are shaken up vigorously in it and the debris decanted off. For fixing, the following methods are best: The cleansed worms are transferred to a clean test-tube containing about a third of 1 per cent. saline. They are now violently agitated for several minutes, and then at once there is poured in an equal amount of saturated corrosive if the specimens be small, or 10 per cent. formalin if large, and the shaking continued as vigorously as before for several minutes longer. The flukes then should be found dead and fixed in an extended condition. They may be left in the fixing fluid for some little time, but should later be well washed in water and preserved in 70 per cent. alcohol if small, or in weak formalin if large. For detailed examination the *Fasciolidæ* and *Schistosomidæ* should be cleared in creosote, but the thick and fleshy *Paramphistomidæ* require sectioning. *Paramphistomes* that have lain for some time in formalin may be successfully reduced to serial ribbons within a few hours by transference to acetone direct, or after rapid passage through spirit. After a couple of hours, dehydration may be tested by clearing in aniline oil, it being necessary to return the specimens thus cleared to fresh acetone. When dehydration is complete the specimens are transferred to a warm mixture of acetone and paraffin, and infiltration is rapidly effected under an exhaust pump. By this method for hastening the parasites through the dehydration stage, their tissues escape the hardening that renders the serial sectioning of Trematoda, prepared by older methods, exceedingly difficult and exasperating.

Method of hardenin

NEMATODA

? Family, GNATHOSTOMIDÆ. Genus, *Tanqua*

Tanqua tiara, v. Linstow, 1906.
Ascaris tiara, v. Linstow, 1879. *Würtemb. Nat. Fahresb.*, p. 313.
Ctenocephalus tiara, v. Linstow, 1906. *Spolia Zelanica.*

Egyptian Monitor lizard, *Varanus niloticus*. Intestine. Taufikia, White Nile.

Tanqua tiara was first recorded from Natal, where it was found to occur in *Varanus ornatus*, Daud. Later its presence was noted in the Bengal Monitor, *Varanus bengalensis*, Daud. Its discovery in the Egyptian Monitor is apparently new. A very similar form from *Hydrosaurus bivittatus* has recently been sent to the London School of Tropical Medicine by Dr. Stanton, from the Federated Malay States. There is considerable doubt as to the systematic position of v. Linstow's genus. *T. tiara*, the type species, was originally described as an *Ascaris*, owing to the deceptive resemblance of the transversely grooved cuticular shields that protect the paired lips, to the typical arrangement of the *Ascaris* lips. The curious shape of the anterior end of the body, the bilabial mouth, the presence of four cervical glands of distinctive form and position, the disposition and small number of the papillæ surrounding the genital aperture in the male, are all characters of generic import that *Tanqua* has in common with *Gnathostomum*. Thus *Tanqua* is more entitled to a place in the Family *Gnathostomidæ* than in *Ascaridæ*.

Nematodes

Family, METASTRONGYLIDÆ. Sub-family, Trichostrongylinæ. Genus, *Hæmonchus*

Hæmonchus contortus

Sheep, *Ovis aries*. Stomach. Nasser, Sobat River.

One or two examples of *H. contortus* were present in the tube containing a quantity of amphistomes from the stomach of a sheep. This parasite is practically world-wide in its distribution, and its occurrence in the Sudan calls for little remark. It affords, however, an opportunity to dwell upon the classification of the various species that formerly were grouped together into the unwieldy genera *Strongylus* and *Sclerostomum*. Under the former name Stossich quotes in 1899 no less than forty-two species, and in the latter, twenty-six. Since then seventeen others have been added. *Strongylus* and *Sclerostomum* were used by Stossich as generic names under which to group two distinct types found in those Nematoda the males of which possessed a rayed bursa, viz. those with simple unarmed mouth and those with chitinous mouth-capsule, and into these two large genera he brought a number of others that more or less exhibited these characters, regarding their names as synonyms.

Identity of *Strongylus* and *Sclerostomum*

Stiles has recently shown, however, that the type-species of *Strongylus* is, undoubtedly, *Strongylus equinus*, which is *also* a type of *Sclerostomum*, so that these two generic names are synonymous, and the more recent *Sclerostomum* must give way to the older name, *Strongylus*. The genus *Strongylus*, moreover, must now include primarily its own type species, and thus, in any division of the various bursate forms, the name must apply to the section containing an armed mouth-capsule similar to that of *Strongylus equinus*—an exactly opposite result from the definition determined upon by Stossich.

Further, it is certain that the several old genera suggested by Molin, such as *Deletrocephalus*, *Diaphanocephalus*, *Echinocephalus*, *Eucyathostomum*, *Globocephalus*, *Histiostrongylus*, *Kalicephalus* and *Metastrongylus*, and afterwards suppressed as synonyms in these two large genera, must be reinstated in any modern classification that recognises distinctive design in the body as a whole, and in its various parts as of generic value, and regards species as stable variations, minute but decided in themselves, in the repetition of a particular design.

The bursate Nematodes

It appears to me that the characters of the mouth armature in the bursate Nematodes must be recognised as of higher than generic value, and our present knowledge of the internal anatomy of the various genera of Strongyles calls for their re-grouping into three separate families, somewhat after the following manner:—

Strongylidæ	Metastrongylidæ	Eustrongylidæ
Nematoda with chitinous mouth-capsule, and a bursa in the male with true rays. Two spicules	Nematoda with simple mouth, and a bursa in the male with true rays. Two spicules	Nematoda with simple mouth, and a cuticular bursa in the male without rays. One spicule

Strongylidæ

Anchylostominæ	Strongylinæ	? n. sub-fam.
Dilated mouth-capsule guarded by teeth or cutting plates, curved dorsally	Dilated mouth-capsule guarded by a ring of setæ "corona radiata" situated terminally	
Anchylostomum Necator Uncinaria	Strongylus Triodontophorus Gyalocephalus Cylichnostomum Eucyathostomum Œsophagostomum	Kalicephalus etc.

Metastrongylidæ

Trichostrongylinæ, n.n. Vagina short, uteri divergent, and musculature differentiated into ovejectors	Metastrongylinæ, n.n. Vagina elongate, uteri lie close together and have simple musculature
Trichostrongylus	Metastrongylus
Ostertagia	Protostrongylus
Nematodirus	Pseudalius
Hæmonchus	Pharurus
Cooperia	

Family, Spiruridæ. Genus, *Spiroptera*

Spiroptera megastoma

Mule. Attached to stomach mucous membrane. Wau, Bahr-El-Ghazal.

Spiroptera megastoma is a stomach parasite of equines that is too well known, both in Egypt and Europe, to require more than a note of its occurrence in the Sudan.

Family, Filaridæ. Genus, ? *Filaria*

Filaria, sp.?

Bat—*Megaderma frons.* Body cavity. Bor, Jebel River.

A single specimen was found in the body cavity of a bat, *Megaderma frons.* It measures 20 mm. in length, is immature and a female. Accordingly it does not provide sufficient data for determination as any one definite species. The absence of a male is very regrettable, as *Filariæ* appear to be very rare in the Vespertilionidæ. Rudolphi records *Filaria vespertilionis* from *Vespertilio discolor, V. bechsteinii,* and v. Linstow *Filaria vesperuginis* from *Vesperugo serotinus,* to neither of which our specimen is likely to belong. *Filaria*

Filaria agamæ. Rodhain, 1906

Lizard—*Agama colonorum.* Embryos in blood. Wau, Bahr-El-Ghazal.

This is a short, stout and sheathed embryo measuring about 66μ, the sheath being about a third longer. Rodhain has described and figured it in "Centralbl. f. Bakt. u. Par.," XLI., Abt. 1, Orig. 1906, p. 545. The adults were found by him in the cellular tissue beneath the skin, but were lost in transit and have consequently not been described. Dr. Wenyon came across the embryos only. The name *F. agamæ* was used only incidentally by Rodhain in an explanatory note that accompanied the figure, and does not appear in the text. There seems no objection to its adoption, though its use was probably intended for descriptive rather than systematic purposes. *Filaria agamæ*

Genus, *Filaria*

Filaria bufonis, sp. nov.

Toad—*Bufo regularis.* Connective tissues. Nasser, River Sobat.

Relatively few filaria have been noted in the Amphibia. Stossich was able to collect only seven known forms for his monograph in 1897. I have found no records of further finds since that time. *Filaria bufonis*

Dr. Wenyon mentions in his notes that the embryos of this filaria are exceedingly common in the blood of toads at Nasser. Of the five adult specimens collected, four were female, one male, the former measuring two inches, the latter three-quarters of an inch in length. Both sexes are very delicate and threadlike. The male has the posterior portion strongly curled in corkscrew fashion; the female tail is bent ventrally as a simple hook. The body maintains practically the same diameter throughout its length save at the extremities, the anterior end tapering only a little and being round and blunted; the posterior narrows considerably, and in the female is drawn out to a tapering point from the region of the anus. The surface of the body is smooth and shows no evidence of transverse striation at any part.

The mouth is simple, and is not guarded by cuticular elevations such as have been described for certain of the *Filaria*, e.g. *F. tenebra*, *F. cornuta*, etc. It resembles much more closely the condition found in certain of the human filaria—e.g. *F. perstans*, where there are only tiny touch corpuscles surrounding the oral aperture.

The mouth continues into the œsophagus, 1·5 mm. long, which can be recognised as divided into two portions, an anterior narrow portion, 0·3 mm. in length, without musculature, and a thick muscular portion, four times the length of the preceding, which is continued into the wide cellular-lined chyle intestine to the neighbourhood of the anus. The nerve ring encircles the œsophagus 0·25 mm. from the anterior extremity.

In the male the cloaca opens very close to the tip of the tail (0·07 mm.). Owing to the coiling, the number of genital papillæ, so important in species work, cannot be determined with certainty, but there appear to be two pairs of pre-anals, a pair of large fleshy ad-anals, and three pairs of post-anals. There are two unequal spicules—simple tubular in structure, tapering distally—the longer measuring 0·26 mm., the shorter 0·11 mm. The testicular tube extends forwards to within a short distance (0·3 mm.) of the junction of œsophagus with chyle intestine.

In the female the anus lies about 0·36 mm. from the posterior extremity. The ovarian and uterine coils fill the greater portion of the body cavity, and their windings give the worm a rope-like appearance under the microscope. These coils only cease their forward extension in the body cavity at about 0·7 mm. from the head. The vaginal opening is situated 1·2 mm. The worm is viviparous.

Filaria Embryos

Dr. Wenyon notes the occurrence of *Filaria* embryos in the blood of the Francolin partridge and of the guinea fowl. The two varieties in the latter were previously noted by Neave (1906). In none of the birds examined were adult forms discovered.

Family, PHYSALOPTERIDÆ

Genus, *Physaloptera*

Physaloptera quadrovaria, n. sp.

Egyptian Monitor Lizard. *Varanus niloticus*. Intestine. Taufikia, White Nile.

Physaloptera quadrovaria

The distinctive and most remarkable character of this parasite is the re-duplication in the female of the usual pair of ovarian tubules that is typically found in Nematoda. In *P. quadrovaria* the vaginal canal is formed by the fusion of four distinct ovarian tubes.

Fig. 43.—Division of the uterus of *Physaloptera quadrovaria* into four ovarian tubules.
ut. = uterus.
ov. t. = ovarian tubules.

The genus *Physaloptera* is but scantily distributed among the Lizards. Rudolphi mentions two forms, *P. retusa* and *P. abreviata*, and Parona has added a third, *P. varani*, as parasitic in Monitors and their allies.

Family, Ascaridæ

Genus, *Heterakis*

Heterakis numidæ, n. sp.

Guinea fowl. *Numida ptilorhyncha.* Intestine. White Nile.

This parasite appears to infest the guinea fowl of tropical Africa in a marked degree. Large numbers were collected from several birds by Dr. Wenyon in the Sudan, and I have obtained it also on various occasions during a recent collecting tour in Uganda. The arrangement of the genital papillæ is peculiar, but in its mouth parts it appears to resemble somewhat closely a larger species, *H. compressa*, described by Schneider and obtained from a domestic fowl of Australia.

The parasites are of a whitish colour, are stoutly built and fairly thick, measuring in length 17·5 mm. in the male, 25 mm. in the female. The sexes are not easily distinguishable by the naked eye, but the males are more truncate at the posterior extremity than are the females.

The mouth is guarded by three large distinct lips such as are found always in *Heterakis* and *Ascaris*. There are no intermediary lips. Just after its origin each lip is slightly constricted laterally, and then expands into a wider distal portion that is in general shape triangular, with each angle distinctly rounded off as a well-marked protruding lobe (*see* Fig. 44, A). The fleshy pulp contained within each lip is shaped pretty much after the same fashion. It is indistinctly lobed but is undivided, thus resembling closely the condition described by Schneider for *H. compressa*, in contradistinction to that occurring in other *Heterakis*. Along the inner edge the lips have a band with a finely striated surface. There are no indications, however, of true teeth.

The œsophagus is muscular, slightly bulbous, and is 15 mm. long.

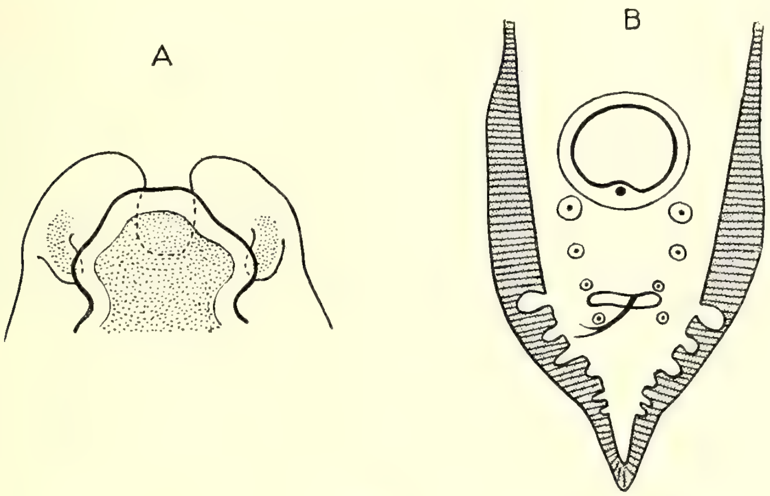


Fig. 44

Heterakis Numidæ

A = mouth parts. B = ventral aspect of tail of male showing papillæ

In the male the posterior end of the body is provided with narrow, thick, cuticular expansions, extending forwards to disappear at about 0·8 mm. from the tip of the tail. Upon the area of the ventral surface thus enclosed three anatomically important features are seen. The genital opening 0·25 mm. forward from the tail-tip, and, again a further 0·15 mm., the ventral sucker with chitinous ring-like edge. The third and specifically most distinctive character is the arrangement of the genital papillæ. In this species there are no papillæ situated either at the side of or anterior to the cuticular ring of the ventral sucker. Between this and the cloaca, and lying within the external range of these two structures, are three pairs of sessile papillæ. The last pair lie just in front of the angles of the cloaca.

Of post-anal papillæ there are seven pairs: two ventral, in line with the pre-anals and sessile; five external, large, fleshy and supporting the cuticular expansions. The first pair of sessile ventral papillæ are small, and are situated immediately behind the angles of the cloaca; the second pair lie at the base of the third set of externals. The five pairs of external post-anal papillæ decrease in size and importance from before backwards. The most anterior lie almost ad-anally, and are by far the most conspicuous. The second and third pair are equidistant from the first pair, from one another, and from the succeeding fourth and fifth pairs, which are very small, slender, and lie close together. The spicules are two in number, they are of equal size, long and slender, with slightly sickle-shaped curve at their distal extremity. They measure 0·9 mm. in length.

In the female the genital pore lies almost exactly in the middle of the body. The vagina passes first of all forwards from the genital opening, and after a very short distance bends backwards, dividing into the two genital tubules which fill the bulk of the body cavity by their windings. The worm is oviparous, the eggs are 0·06 mm. × 0·041 mm. in size, have thick clear hyaline shells and contain morula.

In the female the anus opens 0·6 mm. from the tip of the tail.

The only other detail of interest I need mention here is the presence of many large granular cells in the body cavity. They are very noticeable in many *Heterakis*, but I can offer no explanation of their purpose. They do not come under observation in the closely allied genus *Ascaris*.

Family, STRONGYLIDÆ

Genus, *Kalicephalus*, Molin

Kalicephalus, sp.

Psammophis sibilans. Intestine. White Nile.

P. sibilans is probably the host of a new species of *Kalicephalus*, a genus founded by Molin in 1861 for certain bursate forms from South America, and since regarded by many as belonging to the genus *Strongylus*. There can be no doubt from the mouth armature of the species described by Molin that the forms he examined belong to a properly separate genus, and that the specimens from *Psammophis sibilans* obtained by Dr. Wenyon are quite rightly to be placed under that group; but there does not appear in the descriptions given by Molin of the several original species of the genus sufficient detail to indicate upon what characters the differentiation of the species is to be made, and until such details are forthcoming regarding the species already named it is impossible to state exactly that the parasites now examined do not tally with one or other of them, although the difference in host and in geographical distribution renders it very likely that the forms described by Molin are specifically distinct.

ACANTHOCEPHALA

Genus, *Echinorhynchus*

Echinorhynchus segmentatus, Marval, 1902

Guinea fowl. *Numida ptilorhyncha.* Intestine. White Nile.

Echinorhynchus segmentatus

This species has been recently described and figured in the *Archives de Parasitologie*, Vol. V., p. 412, etc., in a paper, "Étude sur quelques Échinorhynques d'Oiseaux," by L. du Marval. To the naked eye the specimens bear a very close resemblance to Cestodes, owing to the transverse markings of the surface of the body.

Trematoda

Family, Paramphistomidæ. Sub-fam., *Paramphistominæ*

Genus, *Gastrothylax*, Poirier

Gastrothylax wenyoni, n. sp.

Mrs. Gray's Waterbuck. *Cobus Maria.* Stomach. Taufikia, White Nile.

This parasite was obtained in large numbers from the stomach of a waterbuck. The fixation was very good, and perfect serial sections were obtained illustrating all the various structural details. Like its congeners, it has a strikingly red coloration which remains after preservation in alcohol or formalin. This appearance in itself distinguishes the species of *Gastrothylax* at once from other Paramphistomes, and the diagnosis may most rapidly be confirmed by observation of a pore upon the ventral surface a little behind the anterior extremity and additional to the two terminal pores met with in the *Paramphistomidæ.* This pore gives exit to a large spacious pouch that occupies a considerable part of the interior of the *Gastrothylax* body, extending backwards to the anterior limit of the musculature of the posterior sucker. A rough transverse cut of the body reveals the large cavity to the naked eye, and clinches the diagnosis without microscopical study. Although this ventral pouch is absolutely constant, and is indeed not only the chief characteristic of the genus but a feature also in the variations of its shape and extension, in the differentiation of species, yet we still know nothing of its function. It ends blindly, receives only the genital pore in its anterior portion, and is found never to contain undigested stomach contents of its host, or indeed any solid substances (Fig. 47). *Gastrothylax*, Poirier

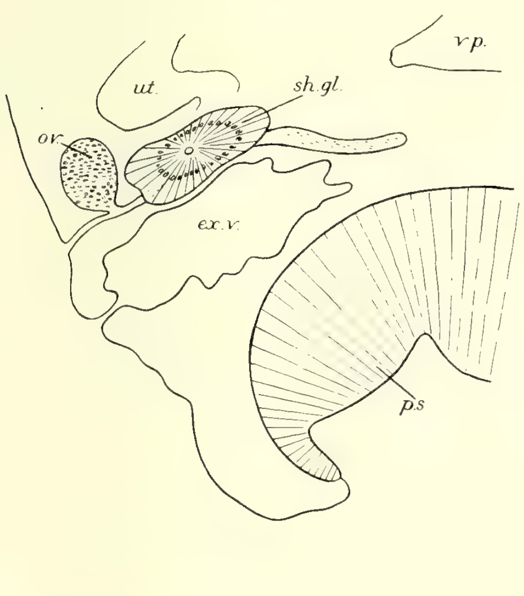


Fig. 45.—Longitudinal section of *G. gregarius*, showing disposition of female reproductive organs and excretory vesicle.

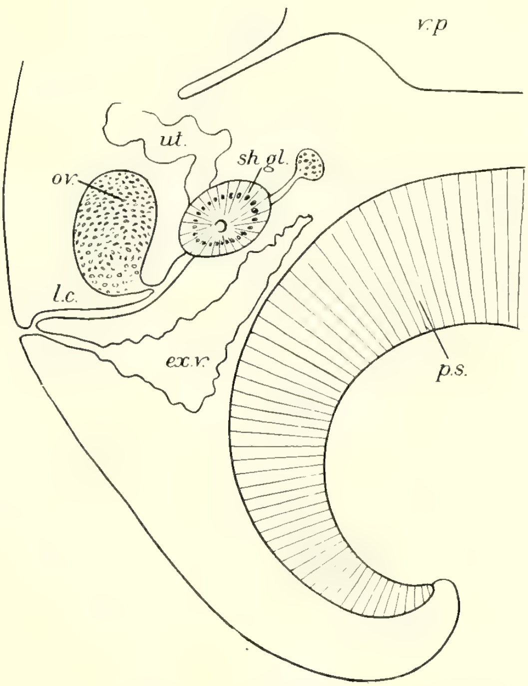


Fig. 46.—Longitudinal section of *G. wenyoni*, showing disposition of female reproductive system and excretory vesicle.

v.p. = ventral pouch.
ex.v. = excretory vesicle.
sh.gl. = shell gland.
p.s. = posterior sucker.
ov. = ovary.
ut. = uterus.

The nine species that have been allocated to this genus have been recently grouped by Fischöder according to the configuration of the buccal pouch in section across the body of the animal.

Transverse section of the pouch is triangular with dorsally directed apex in :

Apex pointed	*G. crumenifer*	from	*Bos taurus indicus*, B. kerabau, India.
	G. compressus	,,	*Bos taurus indicus*, India.
Apex bifurcated—	*G. gregarius*	,,	*Bos bubalus*, Egypt.

Transverse section of the pouch is round in :

G. spatiosus from *Bos taurus*, Arabia.

Transverse section of the pouch is triangular with ventrally directed apex in :

G. synethes	from	*Bos taurus*, East Africa.
G. mancupatus	,,	*Bos taurus*, East Africa.
G. cobboldi	,,	*Bos taurus*, China.
G. elongatus	,,	*Bos taurus*, Ceylon.
G. minutus	,,	*Tragelaphus scriptus*, German Cameroons, Africa.

It will be seen from the above table that of the nine species recorded four are now known to occur in Africa, and that all save one are parasites of cattle.

The specimens from the waterbuck show in transverse section a ventral pouch having a triangular outline, the apex of which is directed dorsally and divided at its tip by a ridge of tissue containing uterine coils and vas deferens (Fig. 48, B, C), thus resembling *G. gregarius*. The Laurer's canal and the excretory duct unite to discharge by a common aperture—a condition quite unique in the genus, and one which, with a notable difference in the shape of the excretory vesicle itself and in the relationship thereto of its efferent duct, suffices to distinguish this form from all others (Fig. 46). I therefore recognise it as a new species, *Gastrothylax wenyoni*.

Gastrothylax wenyoni

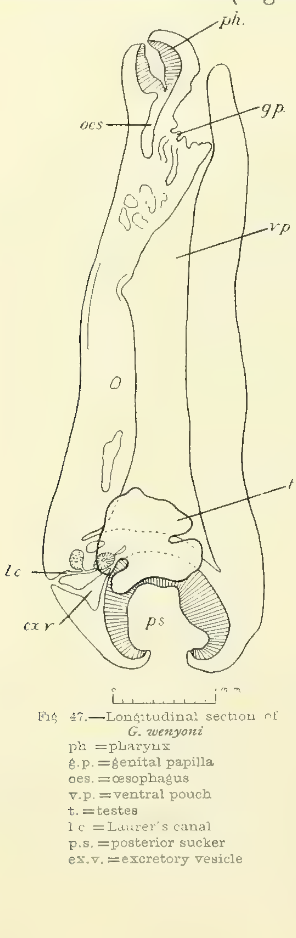


Fig. 47.—Longitudinal section of *G. wenyoni*
ph. =pharynx
g.p. =genital papilla
oes. =œsophagus
v.p. =ventral pouch
t. =testes
l c =Laurer's canal
p.s. =posterior sucker
ex.v. =excretory vesicle

G. wenyoni measures from one third to one half inch in length and has a greatest transverse diameter equal to a third of the body length. It is pyriform in shape, the two bulgings just in front of the posterior sucker being due to the large testes.

The following characters are revealed in serial section ; the measurements given are from a specimen, so prepared, that measured 6·3 mm. × 2·1 mm. greatest diameters. Both suckers, anterior and posterior, are situated quite terminally.

The posterior sucker is almost spherical in outline, its greatest transverse diameter is 1·2 mm., its vertical 1 mm. The entrance to the sucking cup is 0·36 mm. across. The musculature in its greatest thickness, 0·44 mm. The oral sucker is smaller than the ventral and is distinctly apple-shaped, 0·5 mm. × 0·5 mm. ; it is continued by a narrow muscular œsophagus, 0·7 mm., which bifurcates into the two main gut branches just below (0·2 mm.) the level of the

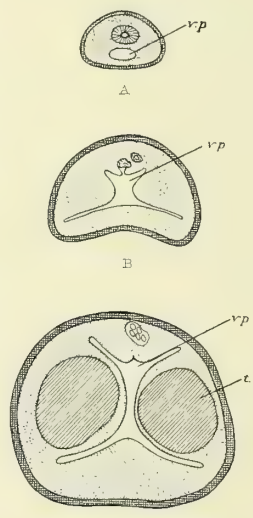
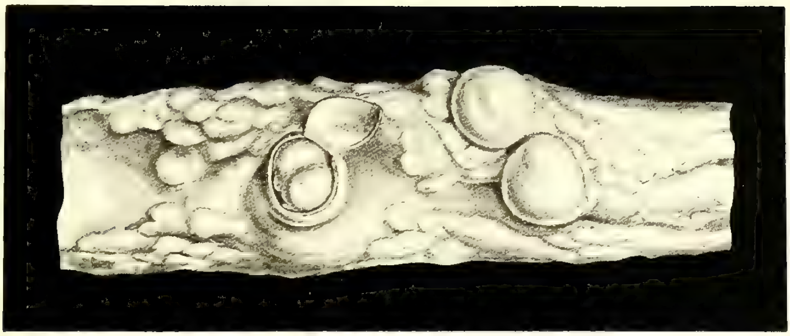


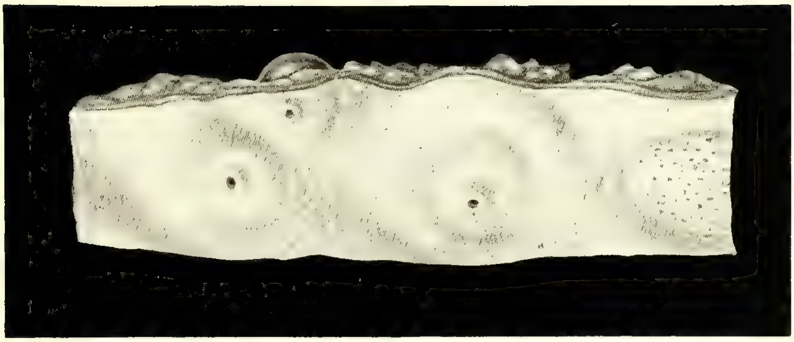
Fig. 48.—Transverse section of *G. wenyoni*
(A) in region of pharynx
(B) at level of genital papilla
(C) region of testes
v.p. = ventral pouch t. = testes

PLATE XXI



1

A. W. Butterworth



2

A. W. Butterworth

Balfouria monogama

Intestine of Marabou Stork showing cysts of *Balfouria monogama*, n. g., n. sp.

1. Peritoneal surface, the cyst on the left side has been dissected to expose the contained worms
2. Mucous surface of gut showing pores leading into the tumours

genital pore. The gut branches fall short of the anterior limit of the testes by almost a millimetre.

As before mentioned, the genital system discharges into the spacious ventral pouch, which in this species has the configuration found in *G. gregarius*. The genital pore lies at the bottom of a distinct depression, the sides of which are covered with papillæ. The posterior edge of this depression protrudes so as partly to shut off the inner portion of the ventral pouch. The genital apparatus does not appear to differ in any marked respect from that of *G. gregarius*. The vas deferens discharges upon a small genital protuberance. The two testes lie on either side and overlap the dome of the posterior sucker. They measure 9 mm. vertically, 1·1 mm. transversely. The disposition of the female genitalia is illustrated in the accompanying Fig. 46. It will be noted that the ovarium and shell gland together with the excretory vesicle lie well to the dorsal side of the animal and are not wedged in between the dome of the ventral sucker and the posterior wall of the ventral pouch. The excretory vesicle is somewhat triangular in median section, and its discharging canal tilts a little forwards to meet Laurer's canal before piercing the dorsal integument. In *G. gregarius* the excretory vessel has a more oval shape and its duct passes backwards to open some distance behind the aperture of Laurer's canal (Fig. 45).

Family, Fasciolidæ

Genus, *Balfouria*, nov.

Balfouria monogama, n. sp. Plates XXI. and XXII.

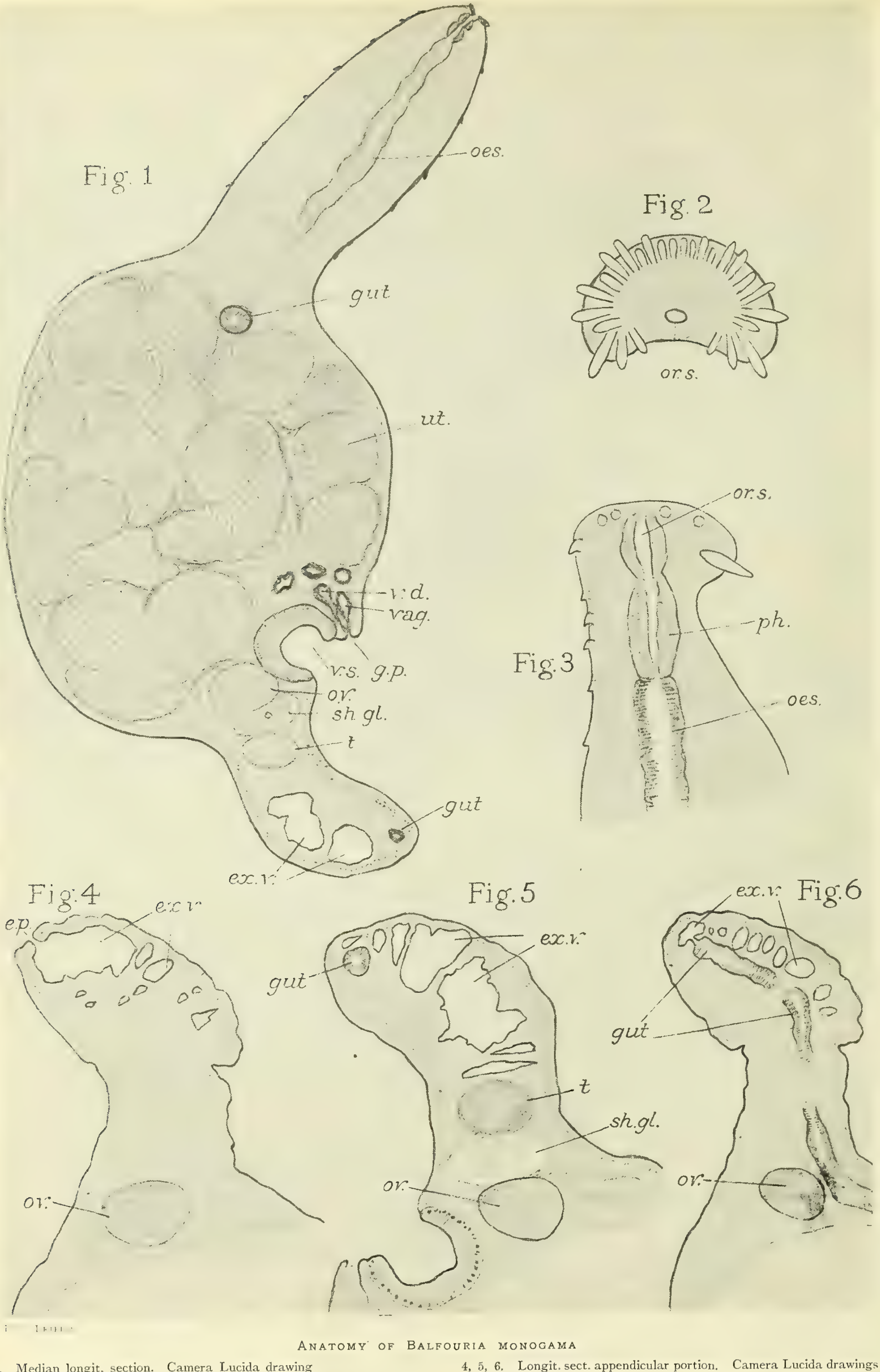
Marabou Stork. *Leptoptilus crumeniferus*, Cuv. Intestinal mucosa (encysted). Taufikia.

In the course of dissection of a Marabou stork, Dr. Wenyon met with an exceedingly curious condition of tumour formation upon the peritoneal surface of the intestines. These tumours (Plate XXI., fig. 1, to right) are tense and hemispherical, with a smooth glistening surface, and measure about half an inch in diameter. They do not invade the mucous membrane of the gut to affect it pathologically, but there opens into each from that aspect a tiny pore (Plate XXI., fig. 2). When cut into (Plate XXI., fig. 1, on left) each tumour is found to contain quite constantly a single pair of sexually mature flukes lying with their ventra in close apposition.

Such a mode of life is highly exceptional in the *Distomidæ*, particularly as each worm is hermaphrodite and both sets of genital organs are functionally active. Brandes describes a somewhat similar condition of encystment for *Distomum turgidum* in the intestine of the frog, but the number of worms in a tumour varied and each worm was enclosed in a distinct capsule. *Distomum okenii* occurs encysted in the gills of *Brama raji*, but the parasite is unisexual, each cyst containing a single paired male and female worm. The form and structure of the parasite in the Marabou stork are so highly characteristic that it deserves, apart from its curious mode of existence, to be grouped apart; and I accordingly propose to create a new genus, *Balfouria*, for its reception, whilst *monogama* would probably be an acceptably descriptive name for the type species.

B. monogama measures about 9 mm. in length, and the body may be recognised as divisible into three parts: a pyramidal anterior portion having the mouth at its apex, a rotund pea-like central portion filled with ova, and a posterior thumb-like "appendix" that is ventrally bent and contains the genital and excretory organs (Plate XXII., fig. 1). The ventral sucker lies at the junction of second and third portions. Save for the appended third portion, the shape of the body recalls that of a Gastrodiscus.

The anterior half of the body is armed with rows of very stout chitinous spines that decrease in size from before backwards, those around the mouth being exceedingly strong and arranged after a very definite plan (Plate XXII., fig. 2).



ANATOMY OF BALFOURIA MONOGAMA

1. Median longit. section. Camera Lucida drawing
2. View of Mouth and surrounding Spines
3. Longit. sect. of anterior end of body showing pharynx and œsophagus

4, 5, 6. Longit. sect. appendicular portion. Camera Lucida drawings
4. Shows excretory vesicle and pore, and 5. the general disposition, of the organs in this region
6. The exit of the gut-branch into the excretory vesicle

e.p. = excretory pore ex.v. = excretory vesicle g.p. = genital pore oes. = œsophagus or.s. = oral sucker
ov. = ovary ph. = pharynx sh.gl. = shell gland t. = testis vag. = vagina v.s. = ventral sucker

The mouth is provided with a muscular wall, which is succeeded by a pharynx that in turn opens into a long œsophagus. The œsophagus divides into two lateral gut branches at the juncture of the anterior and middle portions of the body, and each branch passes throughout the bulky middle portion between the uterine coils and the yolk glands, and then traverses also the appendix to its posterior extremity, there *discharging into the excretory vesicle* (Plate XXII., figs. 4–6). Such an arrangement is exceedingly rare in *Distomidæ*.

The excretory system consists chiefly of a large vesicle in the posterior half of the appendix. Its wall is very highly convoluted. The excretory pore is situated quite terminally. The whole of the middle portion and the anterior half of the last part of the body is occupied by the genital organs. The genital pore lies just in front of the ventral sucker, and at about 2·3 mm. from the excretory pore. From it the vagina passes forwards to continue as the uterus, the coils of which, greatly distended with ova (·1 × ·045 mm.). fill the whole space within the gut branches. The areas outside the gut branches are occupied by the yolk glands which extend beyond the bifurcation of the gut a short distance into the anterior portion of the body. The ovary is a large ovoid organ (·5 × ·3 mm.) lying 2 mm. in front of the posterior extremity, a little behind and just dorsal to the ventral sucker. Immediately in apposition to its posterior surface is seen the compact structure (·55 × ·2 mm.) into which the shell glands are conglomerated, very similarly to what obtains in the *Paramphistomidæ* (Plate XXII., fig. 5). A Laurer's canal passes directly dorsally from the region of the shell gland. The male genital apparatus is very simple, consisting of a pair of oval testes (·4 × ·3 mm.) lying side by side and closely applied to the shell gland; from them the vasa deferentia pass forwards to form convoluted tubules in a small space just in front of the ventral sucker, and terminate in a muscular walled duct which discharges with the vagina at the genital pore (Plate XXII., fig. 1).

C. Dunn

Fig. 49.—Threshing Dura

C. Dunn

Fig. 50.—Burtas building bamboo huts

Report on Economic Entomology

by

Harold H. King

Member of the Association of Economic Biologists

Introduction

The first six months, following my arrival in Khartoum on 11th April, 1906, were occupied mainly in acquiring some knowledge of the language and agriculture of the country. During five days in May, I was engaged in investigating an attack of the berseem worm—the larvæ of *Caradrina exigua*—on lucerne at the cavalry forage farm at Shendi, and from the 14th to the 17th June was on the estate belonging to the Sudan Exploration Plantation Syndicate Ltd., at Zeidab, locating the breeding place of the mosquitoes that had become a pest there. Itinerary

A month, from the middle of July, was spent on the White Nile, and for a week in September I was assisting in carrying out a campaign against a swarm of locusts at Geili. Two-and-a-half months from the 26th November were occupied in making observations on insect pests in general, and the so-called *Nimitti* in particular, in Dongola Province.

On the 30th January, 1907, I was sent to Zeidab to ascertain the breeding places of the mosquitoes that were said to be the cause of a serious outbreak of malaria on the Sudan Exploration Plantation Syndicate, Ltd., estate, and six weeks later went to Abu Hamed to make similar observations on the sandfly, known locally as "Kilteb."

On the 1st of April I proceeded to Shendi, but the attack of "Asal" on dura, that had been the cause of my journey, was over when I arrived, so, having visited El Damer to suggest means with which to suppress the mosquitoes there, I returned to Khartoum, and ten days later was on my way to Kordofan.

A month was spent in that province, making general observations, followed by two months on the White Nile and the Sobat, occupied chiefly in studying the bionomics of the black seroot, *Tabanus biguttatus*.

On the 11th July I was again in Khartoum, and from that date until the end of September, when I went to England on leave, was engaged in routine work and in endeavouring to suppress some of the swarms of locusts that were making their appearance in Khartoum Province.

I returned from leave on the 28th January, 1908, and ten days later went to Port Sudan and Suakin for the purposes of inspecting the Fumigation Chamber that had recently been erected in the Quarantine grounds at the former place, and to obtain specimens of the mosquito that was reported to breed in salt-water pools. On my way back I spent three days at Erkowit, making general observations on the insect pests, and more particularly on the mosquitoes and other biting flies that occur in that neighbourhood.

While these journeyings have prevented me from doing as much research work on the life-histories and habits of insect pests as I would have liked, they have yet enabled me to obtain a very fair insight into the condition of the inhabitants generally, and the methods of agriculture in vogue in many parts of the Sudan. Without such an insight it is impossible to recommend, with any confidence, schemes for controlling the various pests of man, animals, and crops that are to be found.

As is natural in a large country such as the Sudan, very great differences exist in these conditions and methods. In the extreme south, the actual cultivation of the soil is carried on in such a primitive way that the crops are of hardly any importance except to the natives themselves. These savages, nevertheless, graze large flocks and herds of no mean quality. Biting flies and other blood-sucking animals, such as ticks, are to be found in abundance, and, as many of them are suspected of carrying the various diseases from which the natives and their flocks and herds suffer, much useful work might be done in studying the bionomics of these pests.

Farther north, however, more attention is paid to agriculture proper, and in speaking of the "natives" it is the inhabitants of the Central and Northern Sudan to which allusion will be made.

Native cultivation

The methods of cultivation employed by even these natives can hardly be looked upon as of a very advanced order, their main idea apparently being to follow in the footsteps of their fathers. I have rarely, if ever, noticed any regular system of rotation of crops, and this alone, if carefully carried out, will act as a very considerable check to many insect pests. While some insects are practically omnivorous, the majority confine their attentions to certain food plants, and if these food plants are lacking, they are compelled to go afield in search of them or die of starvation.

Many natives know well that the caterpillars that tunnel in the stems of their dura or devour their forage crops will eventually become moths, but it does not occur to them that these moths will eventually give rise to more caterpillars that will attack their crops in the following season.

I have made it a rule, when recommending remedial measures for insect pests, to endeavour to explain, as simply as possible, the life-histories of the latter, but though the native will appear politely interested and amused, he has no serious intention of adopting these measures; "for," he reasons, "there always are worms in the dura stalks, but we generally get some dura, so why worry and take unnecessary trouble; besides, the worms are already in this crop and it is a long time before the next."

If they see one of the species of dura bugs swarming on their dura and obviously ruining it, they are quite keen to adopt any method of catching them, or driving them away. It seems to them, however, to be very unnecessary, when once the crop is harvested, to destroy the same bugs feeding on the wild vegetation adjoining their cultivations in order to prevent their recurrence in the ensuing year.

Clean cultivation

As is well known to the modern experienced farmer, a very important factor in the control of insect pests is clean cultivation. When a crop has been harvested, all refuse such as the stubble should be collected and burnt. In the case of cotton, where the wood is employed as fuel, it should be removed from the fields and put to that use as soon as possible. One not infrequently sees stray cotton and other plants growing on the banks of the canals and gadwals, and it is on volunteer growths such as these that many insects pass the time that elapses between the harvesting of one crop and the planting of the next.

On no account should the remnants of a diseased crop be allowed to lie about longer than is absolutely necessary. As an example of the harm which may result from such a practice, the case of the Melon Fruit Fly—*Dacus* sp.—may be quoted.

It is no uncommon occurrence for melons to decay instead of ripening, and if one of these melons is cut open it will usually be found to contain numbers of creamy-white maggots—the larvæ of a small brown and yellow wasp-like fly, the so-called Melon Fruit Fly. The custom in vogue is to merely detach these diseased melons from the plant and throw them to one side. The maggots continue to develop until, having attained maturity, they leave the melon and pupate just below the surface of the soil. About ten days later the adult flies appear, ready to lay their eggs in any melon or cucumber that may be growing in the vicinity.

Now, if these infested melons, instead of being allowed to rot on the ground, were carefully collected and either burnt or deeply buried, the maggots within them would never be able to complete their life-cycle.

While it is not possible to control all insect pests with this ease, yet it is quite true that by destroying all diseased and refuse vegetation, and removing all volunteer plant growths, the majority of them can to a large extent be kept in check.

If once the native could be convinced of the benefits that accrue from clean cultivation and from adopting preventive and remedial measures for insect pests, I believe that he might be prevailed upon to give the matter some consideration. If this is ever to be accomplished I think it will be by the force of example. When he sees land, farmed by Europeans, yielding far heavier and better crops than he can grow by his present methods, there is every likelihood of his arriving at the conclusion that clean cultivation pays.

Unfortunately, few insect pests can be really controlled except by the continued and concerted efforts of all the farmers in the district, and if one man is persuaded to carry out some proposal, he is disheartened if, as is most probable, it does not meet with entire success.

The case of the cotton boll-worm—*Earias insulana*—is a good illustration of this. No single remedy has yet been devised for this pest, but, by collecting infested shoots while the plants are young, burning the remnants of the crop after the cotton has been gathered, destroying all volunteer cotton plants that may be growing in the vicinity, and by making use of trap crops, much good results.

The control of pests, such as locusts, which range over a large area of land, is clearly a matter to be undertaken by the Government, as individual effort, in a thinly-populated country such as the Sudan, is of little avail. I am glad to be able to state that the sum of £E 700 has been granted with which to carry out experiments in this direction during the coming season, and if these experiments meet with success there is reason to hope that larger sums will be forthcoming in the future.

Grant for locust destruction

It is difficult to estimate the extent of the losses suffered by agriculturists in this country from insect pests, but undoubtedly they are very considerable. The value of crops destroyed by locusts alone in the province of Berber during the year 1906 is said to have been £E 30,000.

Losses due to locusts

A great deal might be done to prevent the yearly outbreaks of fever that occur among the natives living on the banks of the Nile in the Northern Sudan during the winter. These are due to the pools which are left in the banks and khors by the falling river and which constitute breeding places for the malaria-carrying mosquito, *Pyretophorus costalis*. The cold weather bringing out the fever in those natives who have suffered from it in previous years, this mosquito is enabled to spread it. Very little care would be necessary in most places to keep these pools paraffined, and thus to render them useless as nurseries for mosquitoes.

The occurrence of fever among natives employed on large artificially irrigated estates, such as the one belonging to the Sudan Exploration Plantation Syndicate, Ltd., at Zeidab, however, requires more serious consideration. Very great and continual care is necessary, under these circumstances, to keep the smaller canals and gadwals free from mosquito larvæ, and consequently the tendency, in some cases, has been to abandon the attempt as hopeless. This way of treating the matter cannot be too strongly condemned. It may not be possible to entirely suppress the mosquitoes under these conditions, but the least that those in charge ought to do is to strive their utmost to keep them in check, and so to lessen, as far as they can, the ravages of malaria.

Malaria at Zeidab

Filth-feeding flies

The common house-fly—*Musca domestica*—and its relatives are also worthy of some attention. The average native, though cleanly in his person, has no modern ideas as regards the disposal of excreta and refuse, with the result that the majority of the villages that one visits swarm with refuse-feeding flies, which are not only exceedingly annoying, but are also a source of danger. It is a well-established fact that many diseases, such as enteric and cholera, are carried and spread by these flies, which will cheerfully settle on one's food after having, perhaps, only a few minutes before been engaged in walking about and laying their eggs on the most disgusting filth they can find.

Ticks

Since the Second Report of the Laboratories was issued, the human tick—*Ornithodoros savignyi*—has been found to occur in this country. One of its favourite resorts is under trees in the vicinity of desert wells, where it patiently waits for an opportunity of biting the traveller while he indulges in a midday siesta. In other countries a closely allied tick—*O. moubata*—is the carrier of the disease known as "Tick fever," so, although this malady has not yet been noticed in the Sudan, it is advisable to take every precaution against the human tick when journeying in the desert.

Seed and nursery stock

Great care should be exercised in obtaining seed and nursery stock, to get it free from both insect and fungoid pests. Many insects in their native lands are so kept in check by their natural enemies as to be hardly noticeable, but when taken to a new locality, either on nursery stock or in some other way, their natural enemies are frequently left behind, and, as a result, the insects are enabled to increase in numbers to such an extent as to become very serious pests.

Particularly is this the case with nursery stock imported from abroad. At present, citrus and other trees and ornamental shrubs growing in the Sudan are remarkably free from what are popularly known as "Scale" insects or *Coccidæ*. In many countries, including Egypt, this is far from being the case, so, in view of the danger of these and other insect pests being introduced into this country, an air-tight chamber, suitable for the fumigation of imported nursery stock, has been erected in the Quarantine grounds at Port Sudan, at a cost of £E 98. An application for a similar chamber to be erected at Halfa has recently been granted, and, in future, all nursery stock, before being allowed to enter the country, will be subjected to an inspection at the port of entry. Stock found to be grossly infested with scale or other injurious insects will be destroyed outright, while stock apparently clean or only slightly infested will be fumigated with hydrocyanic acid gas before being permitted to go to its destination. Stock so treated and passed will, when possible, be again inspected shortly after it has been planted out, and, if scale or other injurious insects are found to be still present on it and likely to be a source of infection to other stock, the grower will be called upon to take immediate steps to eradicate it.

Fumigation chambers

At first sight this may seem to be placing an unnecessary obstacle in the way of those energetic farmers who are endeavouring to plant orchards and vineyards, and to introduce new flowers and fruits; but when it is remembered that scale-infested stock will not only fail to thrive, but will also be a source of infection to trees and plants already growing in the country, it will be seen that these measures will be of the utmost value to agriculturists throughout the Sudan, by enabling them to obtain clean stock, and guarding their farms from the introduction of many noxious insects.

Issue of pamphlets

The advisability has been discussed of issuing, from time to time, pamphlets, printed in both English and Arabic, dealing with the more common and important of the insect pests. It is possible, if funds are forthcoming, that this may be done during the coming year.

Mr. F. V. Theobald has contributed a paper on mosquitoes, giving a synoptic table of all those species recorded as occurring in the Sudan and describing six new species and a new sub-species. Mosquitoes

A few notes on fungoid pests are included in this report, and it is hoped that they may be of some interest to farmers whose crops suffer from them.

Figures 51 and 52 are reproduced by kind permission of the Editor of the *Journal of the Royal Army Medical Corps.* Plates XXIII., XXV., XXVII.–XXXIII., and XXXV. are by Miss C. M. Beard; Plates XXIV. and XXVI. are by Mr. Hereward Dollman.

In conclusion, I wish to express my gratitude for the many kindnesses shown me during the two years that I have been working in the Sudan.

In particular my thanks are due to Mr. Currie, Director of Education, for the help he has given me in many ways—amongst others, by placing the College garden at my disposal for purposes of experiment and observation.

To Mr. F. V. Theobald, Vice-Principal of the South-Eastern Agricultural College, Wye, Kent, I am greatly indebted for much invaluable assistance, both in the identification of insects, and in many other matters connected with this Report. Acknowledgments

Other gentlemen to whom I would express my thanks for their kindness in identifying insects and ticks are Mr. E. E. Austen, Sir G. F. Hampson and Mr. C. O. Waterhouse, of the British Museum, Mr. Robert Newstead, of the Liverpool School of Tropical Medicine, and Mr. Draper, of the Government Gardens, Egypt.

To Mr. C. L. Slade, Town Engineer, Khartoum, I am indebted for notes on the shipworm (*Teredo*), which does a considerable amount of damage to submerged woodwork in the harbour at Port Sudan.

Among those who have rendered valuable aid by collecting insects and ticks and by reporting insect pests are Colonel Hunter, Major Dansey Browning, Captain Ensor, Captain Mackenzie and other officers of the Egyptian Medical Service; El Kaim. Olver Bey and El Bimb. Williams, of the Veterinary Service; El Kaim. Burges Bey, El Bimb. Hills, Mr. Butler, Superintendent Game Preservation, the Inspectors of the Agriculture and Lands Department, and many of the Governors and Inspectors of Provinces. To these and to many others, whose names are too numerous to mention, I would here express my very hearty thanks.

Animals injurious to Man and Animals

Mosquitoes

A large number of mosquitoes have been collected in various parts of the country during the past two years. Among them are representatives of six new species and a new sub-species.[1] Mosquitoes

Beginning with the northern provinces, Dongola appears to harbour but few of these pests. During the winter 1906–7 some of the village wells contained *Culex fatigans* larvæ, while *Pyretophorus costalis* was found breeding in a few pools on sandbanks in the river. *Stegomyia fasciata* probably occurs in the towns, but was not noticed.

The same species occur in Berber Province, where *P. costalis*, bred out in pools left on sandbanks and in khors by the fallen river, is sometimes responsible for a certain amount of fever that prevails during the winter months. The numbers that come from these places are, however, few compared with those that emerge from gadwals and small canals on artificially irrigated farms, if sufficient care is not taken to control them.[2] *P. costalis*

[1] *See page* 249 of this Report.

[2] *See page* 64 of this Report.

Mosquitoes of Red Sea Province

In the Red Sea Province there is a greater variety of species. *S. fasciata* was common at Port Sudan and Suakin until measures were taken by the Sanitary Authorities to suppress them. *C. fatigans* is again the well-breeding mosquito, and also occurs in company with *P. costalis* in pools in khors during the dry season. A single specimen of the brilliant black and white *Scutomyia sugens* was taken in February, 1908, on the track leading over the hills between Suakin and Erkowit; while the larvæ of *Theobaldia spathipalpis* was found abounding in streams in the vicinity of the latter place. This mosquito appears to be a strict vegetarian in that locality, for everyone living at Erkowit at the time when there were numbers of them to be found declared that there were no mosquitoes save adjoining the stream by the Mudir's Garden, in which a few *C. fatigans* were breeding.

Salt-water mosquito

A new salt-water breeding mosquito, *Culex salus*, has been found at Port Sudan by Dr. Crispin, who has taken considerable trouble to obtain perfect specimens. This species appears to be very particular as to its breeding places, as so far its larvæ have only been seen in a tub sunk in a certain pit containing salt water, notwithstanding the fact that other similar tubs, also containing salt water, were available in the immediate vicinity. Dr. Crispin once noticed mosquito larvæ in a salt-water pool on the foreshore, but their species was not ascertained.

Rare species in Khartoum

The mosquitoes of Khartoum are dealt with by Dr. Balfour in his Report "Sanitary Notes," but to those mentioned by him, two species, probably brought down by boats, must be added. In August, 1906, a perfect specimen of *Mucidus sudanensis* was taken in the Sudan Club; and in September of the following year a battered and worn female *Chrysoconops aurites* was captured in the Laboratory Garden, while in an adjoining collection of water were some young larvæ, suspected of being the progeny of this female. These larvæ were unfortunately destroyed before they could be identified.

Among the various species from the White Nile are *Culex hirsutipalpis*—previously only recorded from El Obeid—*Ædeomyia squammipenna* and *Mimeteculex kingii*, all taken at Taufikia. The latter is common in the swamps in that locality, but is not so frequently seen on boats on the river. Two specimens of *M. sudanensis* were bred out from pupæ taken from a pool adjoining a native village near Taufikia, and a single specimen was caught by Mr. Goodson at Kodok.

The beautiful *Tæniorhynchus violaceus* also occurs at Taufikia and Kodok.

Mimomyia circumtestacea, *Uranotænia pallidocephala* and its sub-species, *cæruleus*, were all taken on board a steamer on the Upper White Nile.

Banksiella luteolateralis is very plentiful in woods and swamps around Nasser on the Sobat, and is a vicious daylight biter. A single specimen of *Stegomyia argenteopunctata* also came from this locality.

Blood-sucking Insects other than Mosquitoes

Sandflies

(I) *Sandflies*

Nimitti

Simulium griseicollis, Becker

Mitt. aus dem Zool. Mus. in Berlin, II. Bd., 3 Heft. (1903), pp. 78–79

Plate XXIII., figs. 1, 2, 4, 6

During certain seasons of the year, vast swarms of the little sandfly *Simulium griseicollis*—locally known as *Nimitti*—occur in the northern parts of Dongola Province.

PLATE XXIII

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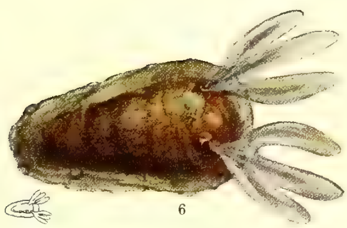


6

7

C. M. Beard

1. *Simulium griseicollis*, Becker. Larvæ and pupæ on a blade of grass
2. *Simulium griseicollis*, adult
3. *Simulium damnosum*, Theob., adult
4. *Simulium griseicollis*, larvæ
5. *Simulium damnosum*, larvæ
6. *Simulium griseicollis*, pupa in cocoon
7. *Simulium damnosum*, pupa in cocoon

Illustrations are natural size unless otherwise indicated

Descriptions of the adults, male and female (fig. 2), were given in the Second Report of these Laboratories.[1] *Nimitti* flies

The *larva* (fig. 4) is ashy grey to greenish in colour, with a pale yellowish brown head. The posterior segments are swollen and the first thoracic segment bears a proleg. Both the proleg and the anal segment terminate in clusters of hooks. Immediately above the anal cluster is a transverse comb of papilli. Two eyes are situated on either side of the head and the mouth is provided with a pair of delicately fringed appendages used in sweeping the food into the gullet. Larva

Length about 5 mm.

The *pupa* (fig. 6) is pale chestnut brown in colour and is enclosed in a semi-transparent, brown, pocket-shaped cocoon, about 3 mm. in length. Projecting above the edge of the cocoon is a pair of white to greyish white respiratory appendages. Each appendage consists of three leaf-like processes, two of which are united at the base. Pupa

Life-history and habits.—The larval stage of the *Nimitti* is passed in the swiftest running water, the eggs probably being deposited in masses on rocks and plants at the water's edge. Life-history and habits

The larvæ, though aquatic, are poor swimmers, so attach themselves to some fixed support and rely on the current to bring their food to them. They are usually particularly numerous on debris—*e.g.* sticks and weeds—caught up among rocks. On their support they spin a network of silken threads by means of which they are enabled to maintain their position against the strongest current. Frequently they will leave their support and let themselves out into the stream anchored by threads of silk and enabled by them to return.

When full-fed, they pupate in small pocket-shaped cocoons attached to the support on which the larval stage has been passed.

The adult emerges in a bubble of air and, having gained the surface, at once takes wing.

Swarms usually consist almost entirely of females. The males are not blood-suckers and are rarely seen in any numbers far from their breeding haunts. Sometimes, however, the first swarms of the season are made up largely of males—this was the case in 1906.

The powers possessed by even the females of actually blood-sucking are very limited, so far as human beings are concerned, as they appear to be unable to pierce the skin except in places such as immediately behind the ear, the forehead, etc. I have never seen them gorged with blood even from these situations. They nevertheless cause intense annoyance both by their habit of crawling into the eyes, ears and nose, and also by continually pricking the skin in their ineffectual efforts to obtain blood.

They feed mainly on birds and animals.

On alighting upon a suitable host—*e.g.* a donkey—the fly creeps down through the hair until it reaches the skin, whereupon it inserts its proboscis and commences to suck blood. In a short time its abdomen becomes enormously distended and the insect then makes its way back out of the hair and attempts to fly. Usually, owing to the quantity of blood it has imbibed, it is unable to proceed more than a few yards before falling to the ground. It then hides itself among the vegetation until the immediate effects of its feast have passed away.

When walking over a smooth surface, the *Nimitti* wave their forelegs, apparently using them as feelers. This habit is common to many of the larger *Tabanidæ*.

[1] Second Report, Wellcome Research Laboratories, 1906, pp. 52, 53.

The first swarms usually make their appearance towards the end of November and the beginning of December, about the time when the wheat is being sown, but are not present in their largest numbers until the months of February and March. Shortly after this they disappear and are not noticed again until the following winter.

They are at their worst during the hours of sunset and sunrise, when it is impossible to walk anywhere with comfort without a veil or smoky torch to keep them away. During the heat of the day, many of them rest among the vegetation ready to attack anything that approaches their haunts.

At night they are harmless.

Their habit of appearing when the wheat is sown, disappearing when the wheat is harvested, and apparently originating among the vegetation, has given rise, among the natives, to the erroneous idea that their presence is entirely due to the wheat.

Nimitti are not usually a pest in Dongola Province, south of Debba, though a stray swarm sometimes reaches Merowe and the district.

A glance at the map of Dongola Province will show that at Debba the Nile makes a pronounced bend.

Cataracts as breeding places

As the river falls in the autumn, the rocks in the cataracts immediately north of Abu Fatma—the Third Cataract—become exposed. The cataracts then constitute ideal breeding places for these tiny sandflies, which shortly afterwards emerge in myriads.

During the winter, the wind blows steadily from the north and the *Nimitti* are consequently borne southwards to Debba, and then, owing to the altered course of the river, on into the desert. In the spring, the wind changes and blows from the south, carrying away with it most of the *Nimitti*. As the summer advances, the river rises, the rocks in the cataracts become covered with water, and suitable breeding places are then few and far between.

The occasional swarms that occur in Merowe and the district are usually to be accounted for by temporary changes in the direction of the wind. Sometimes, however, as in the spring of this year, when the river was exceptionally low, it is possible that rocks become exposed in other parts of the river and the swarms that appear there breed locally.

Sandflies in Khartoum

Nimitti are by no means confined to Dongola Province, though it is usually only there that they occur in very large numbers. Larvæ and pupæ have been taken from the river at Abu Hamed and at Gebel Umali, while adults are frequently seen during the winter in the vicinity of the river from Abu Hamed to Khartoum.

The types from which this species was originally described came from Assuan.

Kilteb fly

KILTEB

Simulium damnosum, Theob.

Reports of the Sleeping Sickness Commission, No. III. (1903), p. 40

Plate XXIII., figs. 3, 5, 7

A second and larger species of sandfly—*Simulium damnosum*—occurs in the Sudan, in the vicinity of the Abu Hamed, where it bears the name of *Kilteb*.

The following is a copy of the original description of the *adult* (fig. 3) :—

"The fly is 3 mm. long, of a general black colour; head palpi and antennæ black, except at their base, where they are bright testaceous; thorax black, the meso-thorax with bright deep golden, thick, short, curved hairs closely applied to the surface of the thorax. Meta-thorax black, abdomen black, shiny with short black hairs; fore and mid legs black; the metatarsi of the hind legs with a broad median pale yellow band; wings bright, testaceous at the base; halteres ochraceous, the metatarsus, and especially the first two tarsi, much swollen in the fore legs, the two last tarsi small, very hairy, less so on the mid and hind legs; ungues all dentate."

Larva

The *larva* (fig. 5) resembles in shape and general appearance the *Nimitti* larva, but can be distinguished from it by its relatively larger size and darker colour. A dark pigmented patch is usually present on either side of the first thoracic segment.

Length about 6 mm.

Pupa

The *pupa* (fig. 7) is enclosed in a pocket-shaped cocoon, about 4 mm. in length, similar to that of the *Nimitti* pupa. The respiratory appendages consist each of a double comb of tubes which do not project much above the edge of the cocoon.

Life-history and habits

Life-history and habits.—The life-history of the Kilteb appears to be identical with that of the *Nimitti*. It has nevertheless been recorded from only one locality in the Sudan—viz., the neighbourhood of Abu Hamed, where its larvæ and pupæ exist in the river in company with those of the *Nimitti*.

The adult females are exceedingly vicious blood-suckers, attacking chiefly the ankles and legs. Like the *Nimitti*, they are most active during the hours of sunset and sunrise.

The Kilteb do not swarm around the face, trying to crawl into the eyes and ears, but each fly, in a business-like way, settles on the spot it has selected, takes a short preliminary tour, patting the surface with its fore legs, and then, plunging its proboscis into the skin, commences to feed. In from two to three minutes it is fully gorged, whereupon it flies heavily away, while a tiny trickle of blood flows from the puncture it has made.

These bites are exceedingly irritating, and in some cases produce considerable swelling.

The types from which *S. damnosum* was originally described came from Uganda, where it is known as *Mbwa* or the *Jinja fly*. The following is an extract from a letter received from Mr. Charles White, of Bukalamu, referring to this fly:—"We have in these parts, near the Ripon Falls, a terrible pest, far worse than mosquitoes—a small black biting fly, which sucks the blood and leaves a painful irritation and sore. Natives have to bind their legs with bark-cloth puttees, and some of their bodies and legs are covered with sores which they tell me are caused by this fly. . . . . These flies are in millions here, and consequently cattle will not thrive."

Kilteb do not occur at Abu Hamed in very great numbers except during the winter, when the river is low.

II. *Seroots*

Seroots

TABANIDÆ

New Sudan *Tabanidæ*

Several species of *Tabanidæ*, hitherto unrecorded from the Sudan, have been taken during the past two years. These include a *Chrysops*—*C. brucei*, Austen—and a *Hæmatopota*—*H. denshamii*, Austen.

Among a collection of blood-sucking flies made by Capt. C. Mackenzie in the Lado Enclave is a member of the genus *Hippocentrum*—*H. versicolor*, Austen—and three *Hæmatopota*—*H. denshamii*, *H. tenuis*, Austen, and a third species that has yet to be determined.

A single specimen of *Tabanus unitæniatus*, a species recently described by Miss Ricardo, was taken at Wau, Bahr-El-Ghazal, in 1905, and *Pangonia magretti*, Bezzi, is recorded from El Obeid, Kordofan, by El Bimbashi Williams.

The following seroots have been taken in Khartoum: *Tabanus socius*, Walk., *T. ditæniatus*, Macq., and a third species new to the Sudan, but which, unfortunately, reached England in too damaged a condition for identification. Doubtless they were brought in on boats or by herds of cattle.

During the summer of 1907 I spent eight weeks on the Upper White Nile and the Sobat, and near Taufikia obtained eggs of the black seroot, *T. biguttatus*, Wied. The larvæ from these were brought to Khartoum and reared in the laboratory.

Among the seroots noticed in the vicinity of Nasser, on the Sobat, were *T. socius*, *T. biguttatus*, *T. africanus*, Gray, *T. fasciatus*, Fab. var. *niloticus*, Aus., and *T. par.*, Walk.

In some localities on the White Nile, *T. africanus*—and probably other species of similar appearance—is known to the natives as *Ter-el-gufar* ("bird" or "flying thing of camel sickness"), owing to the belief that exists among them that it is the cause of the common camel disease. For this note I am indebted to Mr. C. E. Lyall.

Chrysops brucei, Austen

Five females of this species were taken on board a steamer in the Sud region in July, 1906.

The following is a brief description of *C. brucei*, ♀:

Black; thorax with four longitudinal greyish lines. Abdomen with hind margins of segments greyish; a triangular greyish mark on second segment in median dorsal line. Legs ochraceous, front tarsi and last three joints of middle and hind tarsi brown to black; coxæ, trochanters and apices of femora black. Costal border and stigma dark brown, a dark brown transverse bar extending into the anal cell.

Hippocentrum versicolor, Austen

Several specimens, all females, were taken in the Lado Enclave by Capt. Mackenzie in 1907.

♀ *Black; fore tibiæ pale yellow, apically banded black, mid and hind tibiæ very pale yellow; mid and hind tarsi pale yellow with joints apically tipped black. Wings brown with interrupted white transverse bar; Costal border to stigma yellow; stigma yellow and dark brown.*

Head: shiny black. Palpi, shiny black tinged with yellow and clothed with black hairs. First joint of antennæ long, yellowish; second joint very small, yellowish; third joint long, first ring very much longer than the remaining ones, black.

Thorax: shiny black with very faint pale pubescence. Pale hairs on the pleuræ.

Legs: femora black, fore and mid pair slightly tinged with brown. Fore tibiæ pale yellow, apically banded with black; mid and hind tibiæ very pale yellow. Fore tarsi black; mid and hind tarsi pale yellow with joints apically tipped with brown. Clothed with short hairs.

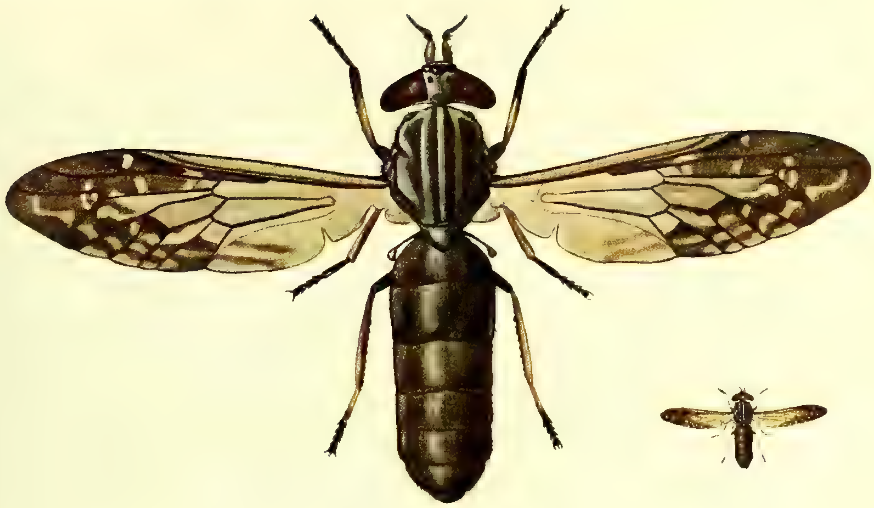
Wings: costal border to stigma and first mediastinal cell yellow; stigma yellow and brown; anterior basal cell and posterior basal cell (except at the apical end), together with the basal ends of the discal cell, the first submarginal and the first posterior cells hyaline with a faint yellowish tinge; basal half of the anal angle hyaline; a white transverse bar crossing from the second mediastinal cell to the fifth posterior cell is broken by the fourth posterior cell being uniformly dark brown; remainder of wing, dark brown.

Halteres: very pale, almost white.

Abdomen: shiny black, with a very faint pale pubescence.

Length: 8–8·5 mm.; width of head, 2·5–3 mm.

PLATE XXIV



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HEREWARD DOLLMAN

1. *Hæmatopota denshamii*, AUSTEN

2. *Hæmatopota tenuis*, AUSTEN

Small illustrations indicate natural sizes

Hæmatopota denshamii, Austen

Plate XXIV., fig. 1

Ann. and Mag. Nat. Hist., Ser. 8, Vol. I., March, 1908, p. 220

Two females of this species were taken by Capt. Ensor in the Southern Bahr-El-Ghazal, and nine of the same sex by Capt. Mackenzie in the Lado Enclave.

The following is the original description :—

" *Length* (6 specimens), 9·6–11·3 mm.; width of wings, 2·8–3 mm.; width of front at vertex, 1 mm.; length of wing, 8·6–10·3 mm.

" *Olive-brown, with five olive-grey longitudinal stripes on dorsum of thorax, and a narrow median light stripe on abdomen; frontal callus black; wings tinged with buff, and with a brown border to the tip and hind margin, as far as the end of the sixth vein; coxæ dark grey, femora olive- or greyish-brown.*

" *Head:* smoke-grey to yellowish-grey, vertex with a pair of faint light brown longitudinal stripes, which meet together above callus; *frontal callus* of moderate depth, its upper margin slightly convex and rising to a point in the median line, which, in rubbed specimens, may be produced into a shining ridge; brown spot on each side of front usually well marked, median frontal spot absent; *palpi* pinkish buff, elongate, blunt at the tips, clothed with black interspersed with light yellowish hair; first and second joints of *antennæ* ochraceous buff, first joint not swollen, expanded portion of third joint dark brown, rufous at the base, last three annuli black, last annulus equal in length to the two preceding annuli taken together.

" *Thorax:* median stripe on dorsum only half as wide as admedian stripes, latter wider in front; pleuræ and pectus olive-grey.

" *Abdomen:* clothed with minute, appressed, buff-yellow hairs; venter olive-grey on each side.

" *Wings:* light markings rather coarse; against a dark background, remains of the usual three rosettes can be distinguished, otherwise the markings are confined to the brown border; two sinuous streaks running across tips of submarginal cells, beyond fork of third vein, the distal streak breaking up into a series of detached markings running across the posterior cells; axillary cell faintly tinged with brown, with a broad pale streak running parallel with the wing-margin and continued along the sixth vein, thus enclosing an area of darker colour; basal, anal, and discal cells, proximal two thirds of first posterior cell, and bases of remaining posterior cells not infuscated; a faint dark marking usually visible across middle of discal cell. *Stigma*, dark brown, conspicuous.

" *Halteres:* light russet to brown, stalk yellowish.

" *Legs:* tibiæ ochraceous buff, clothed with minute ochraceous hairs, distal two thirds of tibiæ brown; front tarsi dark brown, middle and hind tarsi lighter brown, ochraceous buff at base."

The type from which this species was described came from Uganda, Nile Province, in 1906.

Hæmatopota tenuis, Austen

Plate XXIV., fig. 2

Seven females of this species were taken by Capt. Mackenzie in the Lado Enclave.

♀ *Brown; thorax with three longitudinal grey lines; abdomen with a faint grey median line and a row of grey spots on either side; mid and hind tibiæ with two yellow bands, tarsi apically black; wings brown with pale markings; stigma dark brown.*

Head: greyish brown. Callosity shiny yellowish-brown. Antennæ and palpi yellowish clothed with black hairs.

Thorax: brown with three longitudinal dorsal grey lines. Sides of the dorsum and the pleuræ greyish; scutellum brown bordered with grey and with a faint median longitudinal grey line.

Legs: yellowish-brown; mid and hind femora apically dark; fore tibiæ dark, basally yellowish; mid and hind tibiæ dark apically and basally and with a median dark band; tarsal joints apically tipped with black.

Wings: stigma dark brown; discal cell brown, with a pale area at the basal end, two transverse pale median bars and a reniform pale area at the apical end; anterior basal cell with both ends and two median bars pale; posterior basal cell with a circular pale mark enclosing a brown spot at either end; a pale sinuous line extends from the basal end of the stigma through the discal cell and the bases of the fourth and fifth posterior cells into the anal angle, where it encloses a brown spot. For remaining wing markings, *see* Plate XXIV., fig. 2.

Halteres: knob dark brown, stem pale.

Abdomen: brown, with slight pale pubescence; faint grey median longitudinal dorsal line; segments apically edged with grey and each bearing two grey spots on the dorsal surface, one on either side of the median stripe; anal segment dark brown without markings.

Length: 8–9 mm.; width of head, 2·5 mm.

Tabanus unitæniatus, Ricardo.

Ann. and Mag. Nat. Hist., Ser. 8, Vol. I., April, 1908, p. 312.

A single female of this species was taken at Wau, Bahr-El-Ghazal, in 1905.

The original description is appended below:—

"Head, small, broader than the thorax. Face, reddish, covered with grey tomentum and with short, scanty white pubescence; beard, white. Palpi, yellow, thickly covered with black hairs, long and narrow, only slightly broader at the base, ending in an obtuse point. Antennæ, bright red, the extreme apex black; the first joint short, broad, with a few black hairs; the second small, cap-shaped, with black hairs on its upper angle; the third, with an obtuse tooth. Forehead, about four times as long as it is broad and the same width throughout, reddish with some little grey tomentum; the callus shining red-brown, convex, oval, becoming narrower at its lower end, whence proceeds a narrow, short, raised line, which widens to a spindle-shaped callus; from the vertex a narrow black line proceeds in two branches surrounding this last. Eyes with no markings. Thorax, reddish-brown, with traces of grey tomentum and of three stripes, the sides reddish with grey tomentum. Abdomen, narrow, reddish-brown, with a greyish-white median stripe reaching the fifth segment, the apex black, the segmentations very narrowly white, the pubescence on dorsum mostly black; underside testaceous with a black apex, in the other female it is very largely black. Legs, reddish, the femora (especially the fore femora) blackish, the fore tibiæ blackest at their apex, and fore tarsi black. Wings hyaline, the stigma yellowish, the veins yellowish brown (in the other female the fore border has a very slight tinge of yellow); the first posterior cell not narrowed."

The type from which this species was described came from Pungwe Valley, S.E. Africa, in 1896.

The black seroot

Tabanus biguttatus, Wied.

Plate XXV

A short description of the adult forms of this tabanid was given in the Second Report of these Laboratories.[1] They are subject to considerable variations in their

[1] Wellcome Research Laboratories, Second Report, 1906, p. 61.

PLATE XXV

Tabanus biguttatus, WIED.

1. Egg batch on stem of grass
2, 3. Heads and abdomens of ♀ showing variations in markings
4. Adult ♂
5. Mandibles of larva
6. Terminal abdominal teeth of pupa
7. Adult ♀
8, 9. Larvæ

Illustrations are natural size unless otherwise indicated

markings. The type of female most commonly met with has the jowls clothed with golden-yellow hair, and the front (space between the eyes) and dorsum of the thorax with greyish to yellowish-white hair. Another common form has the jowls, front and dorsum of the thorax all clothed with greyish to yellowish-white hair; or the jowls and front may be clothed with golden-yellow hair and the dorsum of the thorax with greyish to yellowish-white. A comparatively rare form has the jowls, front and dorsum of the thorax all clothed with golden-yellow hair; while still less frequently seen is the female bearing on the median dorsal line of the abdomen two or even three white triangular marks.

The male may bear either two, three, or occasionally four white marks on the median dorsal line of the abdomen. Two is the most usual number, and the fourth when present is very small.

The wings show less variation, though sometimes a female is seen with pale areas contained in each of the third, fourth, and fifth posterior, the discal and the posterior basal cells and the basal angle.

The *egg* is spindle-shaped, slightly more pointed at one end than at the other, and white in colour.

Length, 2·5 mm.

The *larva* (figs. 8 and 9), when newly hatched, is white in colour, but later assumes a greyish to yellowish tinge.

Mandibles (fig. 5) black, slightly serrated and with two tufts of curved hairs at the base.

First thoracic segment anteriorly brown. Laterally placed on the second and third thoracic segments are brown comb-like marks with the four teeth pointing backwards.

On the anterior portion of each abdominal segment—with the exception of the eighth—are two brown annuli, or rings, encircling the body. The former of these two rings is usually covered by the posterior margin of the preceding segment. The hinder ring bears a double line of fine black hairs and also a number of small fleshy projections or pseudopods. The eighth abdominal segment serves the purpose of a respiratory syphon. Its posterior margin is brown and from its extremity can be extruded a small process terminating in stigmata. A brown curved longitudinal mark is situated on either side of the eighth segment. The anus is placed at the base of this segment.

Length, 35 mm.

The *pupal case* is chestnut-brown in colour, with the thoracic tubercles darker. Each of these tubercles bears a spine. The abdominal segments are apically ringed with backwardly projecting spines. The anal segment terminates in a cluster of six teeth (fig. 6), the dorsal pair larger than the lateral and ventral pairs.

Length, 20 mm.

Life-history and habits.—The adults may usually be found resting on the trunks and larger branches of trees. Males appear to be more plentiful than females. On the approach of cattle, the latter dart off and attack them, but were rarely seen to follow them for any distance. Both sexes are very wary and are not easily captured.

The eggs are deposited in a rounded mass (fig. 1) on grass and reeds overhanging a pool. One egg mass that was counted contained about 450 eggs. The entire act of oviposition was not timed, but it is a lengthy proceeding and occupies well over half an hour. When a female is ovipositing, although usually exceedingly shy, the stem on which she is resting may be plucked and carried away or put into a bottle without disturbing her. Having deposited her eggs, she covers the mass with a creamy-white secretion which turns black after a short time.

The eggs under observation hatched in about eight days, but possibly under natural conditions, exposed to the sun, the incubation period would be shorter. On hatching, the larvæ fell into the water, swam to the sides and buried themselves in the mud.

The larvæ can only swim on the surface of the water, and progress either by a telescopic movement or by lashing vigorously from side to side.

Several methods of rearing them were tried. The majority were placed in a large glass vessel containing mud, living grass and water. Some were put into jars containing only water, others in dishes containing moist sand, others, again, in vessels containing sand and water so arranged that there was a pool at one end of the vessel and moist sand at the other.

The larvæ in the vessel containing mud, grass, and water did well, but many were devoured by predaceous insects—*e.g.* dragon fly larvæ—introduced by accident in the mud and water, and others perished owing to the grass dying and fouling the water during transit. Eventually sand and water in Petri dishes was found to be best, as it could be kept clean and the larvæ easily located when wanted.

At first they were fed on tiny crustaceans dredged from rain pools, but during transit, when these could not be obtained, scraps of freshly killed raw meat and congealed blood from the bodies of gorged mosquitoes were substituted. After arriving in Khartoum their diet consisted of earth-worms, as a plentiful supply of these could always be procured.

They grew very slowly and at greatly varying rates. Two larvæ hatched from one egg batch on 11th June measured respectively five weeks later, 4 mm. and 15 mm. Owing to their telescopic nature it was exceedingly difficult to measure them accurately, so these figures must be taken as merely approximate.

They did not appear to be cannibalistic in their habits, as several of various sizes were reared in the same dish and sometimes kept short of food, but were never seen to attack each other. When one died, however, its comrades usually devoured it.

When not feeding they spent most of their time buried in the sand, with just the tips of their respiratory syphons showing. If the sand was allowed to dry they became very restless, and would make continual efforts to escape from their jars until water was given them again.

Early in August, when they were about eight weeks old, they ceased feeding and were then transferred to jars containing sand to a depth of 6 cm. They descended to the bottom of these jars and were still there when, some six weeks later, I went to England on leave.

I returned to Khartoum on 28th January, and the jars then contained several dead adults—all males—a few dead pupæ and larvæ and a single live larva. This last perished early in February without having reached the pupal stage. The empty pupal cases were all sticking up out of the sand, the pupæ having evidently worked their way up from the bottom of the jars by means of their abdominal spines. In several cases the old larval skin had remained attached to the caudal teeth of the pupal case.

The eggs from which these seroots were bred were obtained in the marshes in the vicinity of Taufikia.

setse flies

Tsetse Flies

The distribution in the Sudan of the tsetse flies *Glossina palpalis*, Rob. Desv., and *Glossina morsitans*, Westw., has been dealt with by Capt. Ensor, R.A.M.C.[1]

[1] *See page* 93 of this Report.

A dark variety of *G. morsitans* was taken by Major G. Dansey Browning, R.A.M.C., on the road between Sultan Keango's village and Kossinga village in the Bahr-El-Ghazal Province during the winter of 1905–6. The following is his description[1] of this variety:— Variety of *G. morsitans*

"The fly is a dusky black glossina somewhat similar in size and colour to *G. palpalis* but differing markedly from that species as regards the coloration of the tarsi, these being specifically identical with the tarsi of *G. morsitans*. The posterior surface of the head is dusky black, not dusky grey as in *G. morsitans*. The thorax and pleuræ are distinctly dusky black, not dusky grey. The abdomen is markedly darker than in *G. morsitans*, particularly as regards the second segment. On this the pale area found in *G. morsitans* is replaced by a peculiar dusky area with irregular black confluent blotches on a dark ochraceous background. The abdominal bands are generally deeper than in *G. morsitans*, and the hind margins of the segments are narrower and generally more dusky in appearance. In other respects similar to *G. morsitans*."

III. Insects causing Myiasis

The Tumbu Fly

Cordylobia anthropophaga, Grünberg

Some flies in the Laboratory collection sent from the Southern Sudan—believed from the Bahr-El-Ghazal—have been identified by Mr. Austen as the so called *Tumbu Fly—Cordylobia anthropophaga*.

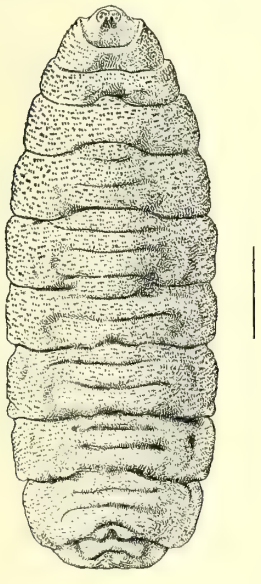

Fig. 51.—Larva of Tumbu Fly.[3]

As Mr. Austen's detailed description[2] of the larva, puparium and adult of this pest may not be easily accessible to many who may meet with subcutaneous parasitic larvæ in the Sudan, it is here given in full, together with his notes on the differences that enable one to readily distinguish between *C. anthropophaga* and the *Congo Floor Maggot—Auchmeromyia luteola*, Fabr.

"*Larva.*—The full-grown larva is a fat, yellowish-white maggot, 12 to $12\frac{1}{2}$ mm. (about half an inch) in length, bluntly pointed at the anterior or cephalic extremity, and truncate behind; its greatest breadth (on the sixth and seventh segments) is 5 mm. The body consists of twelve visible segments, the divisions between which are strongly marked, except between the cephalic and first body-segment (the latter of which bears the anterior or prothoracic stigmata or respiratory apertures), and between the eleventh and twelfth segments. On the under side of the cephalic segment, the tips of the black paired mouth-hooks may be seen protruding, while in a slight depression on the flattened posterior surface of the twelfth segment are situated the paired posterior stigmatic plates. In an adult larva, the slit-like apertures in these plates are not very easy to distinguish, but in a maggot in the second or penultimate stage it is seen that each plate bears three ridges of tawny-coloured chitin; these ridges run obliquely downwards and outwards at an angle of 45° from the median vertical line, and while the median ridge on each plate is nearly straight the other two ridges are characteristically curved, resembling

[1] *Journal of the Royal Army Medical Corps*, April, 1908, p. 427.

[2] *Ibid.*, January, 1908.

[3] Reproduced by kind permission of the Editor (Col. Bruce) of the *Journal of the Royal Army Medical Corps*.

inverted notes of interrogation with the concavity directed towards the median ridge. The segments of the body are transversely wrinkled on the dorsal and ventral surfaces (especially on the latter) and puckered on the sides. From the third to the eleventh segment, the body is thickly covered with minute recurved spines of brownish chitin (darker in the case of larvæ ready to leave the host), usually arranged in transverse series or groups of two or more, which can be seen to form more or less distinct, undulating or irregular, transverse rows. These spines will be described in somewhat greater detail below.

"Above and to the outer side of each mouth-hook is an antenna-like protuberance ('maxilla' of Lowne), which, as in the case of the larva of the Blow-fly *(Calliphora erythrocephala,* Mg.), exhibits a pair of light brown, ocellus-like spots, or rather papillæ, placed one above the other; according to Lowne's interpretation in the case of the Blow-fly, these are sensory in function. In a small larva, 5 mm. in length, from Lagos, the papillæ are very clearly visible; each papilla is surrounded by a ring of pale brownish chitin, and its shape, when viewed from the side, is exactly that of the muzzle of an old-fashioned muzzle-loading cannon.

"This small larva also shows on the basal segments of each antenna, or antenna-like protuberance, below and a little to the outer side of the mouth-hook, a prominence bearing a series of about six small, brown-tipped, chitinous spines. These prominences are evidently the same as those referred to by Coquerel and Modière[1] as 'deux appendices analogues (palpes ?) plus petits, munis de quelques épines très fines vers leur bord interne,' and clearly shown in their figure (Plate 3, 1 b). In the same larva, the spines on the body are most conspicuous, and most strongly developed and chitinised on the fifth, sixth and seventh segments. The tenth and eleventh segments are also covered with spines, but since the chitin of which they are composed is not tinged with brown, these segments appear bare. In the adult larva also, the spines in the tenth and eleventh are less conspicuous than those on the preceding segments; on the twelfth segment, which bears the posterior stigmatic plates, the spines are very minute. Fully chitinised spines are dark brown, but this colour is generally confined to the apical half of the spine, or may be absent from the extreme base. In shape, each spine is a short cone with the apex recurved, pointing towards the hinder end of the body. The spines are broad at the base in proportion to their length and not infrequently, especially on the under side of the body, are bifid at the tip. They are closest together and most strongly developed on the anterior portion of each segment, becoming smaller and showing a tendency to disappear towards the hind margin. They are arranged in irregular transverse rows, which are usually seen to be composed of groups of from two to five spines, placed side by side.

"In the adult larva the median area of the ventral surface of segments five (or six) to eleven inclusive is marked with a series of three transverse ridges, which are most prominently developed on the seventh and following segments. On each segment the foremost ridge is the shortest; next in length comes the hindmost; and the middle ridge is the longest of the three, curling round the posterior ridge at each end. Similar but less strongly marked ridges are seen on the dorsal surface.

"*Puparium.*—Of the usual barrel-shaped Muscid type. Average dimensions: length, $10\frac{1}{3}$ mm., greatest breadth $4\frac{2}{3}$ mm. Though at first of a ferruginous or light chestnut tint, the puparium gradually darkens until it becomes 'seal brown' or practically black.

"*Perfect Insect.*—A thick-set, compactly built fly, of an average length of about $9\frac{1}{2}$ mm.; specimens as small as $6\frac{1}{2}$ mm. or as large as $10\frac{1}{2}$ mm. in length are occasionally met with.

[1] *Annales de la Société Entomologique de France,* 4ième série, t. ii. (1862), p. 97.

Head, body and legs, straw yellow; dorsum of thorax and of abdomen, with blackish markings; wings with a slight brownish tinge. The eyes meet together for a short distance in the median line above in the case of the male, but are separated by a broad front in the female (*see figure*). On the dorsum of the thorax the dark markings, which are a pair of longitudinal stripes not reaching the hind margin, are covered with a greyish bloom and, consequently, not very conspicuous; this bloom is also present on the abdomen, but here the markings are much more distinct, especially in the female, in which the third segment, as also the fourth segment with the exception of the hind margin, is entirely black or blackish. In the female the second segment is marked with a blackish quadrate median blotch, and has a similarly coloured hind border, broadening towards the sides, while the first segment has a narrow dark hind margin. In the male these markings are not so extensive; the dark hind margin to the second segment is interrupted on each side of the median blotch, which is triangular in shape, and there is a yellow area of considerable size on the proximal half of the third segment, on either side of a blackish median quadrate blotch; the fourth segment is similarly but less conspicuously marked.

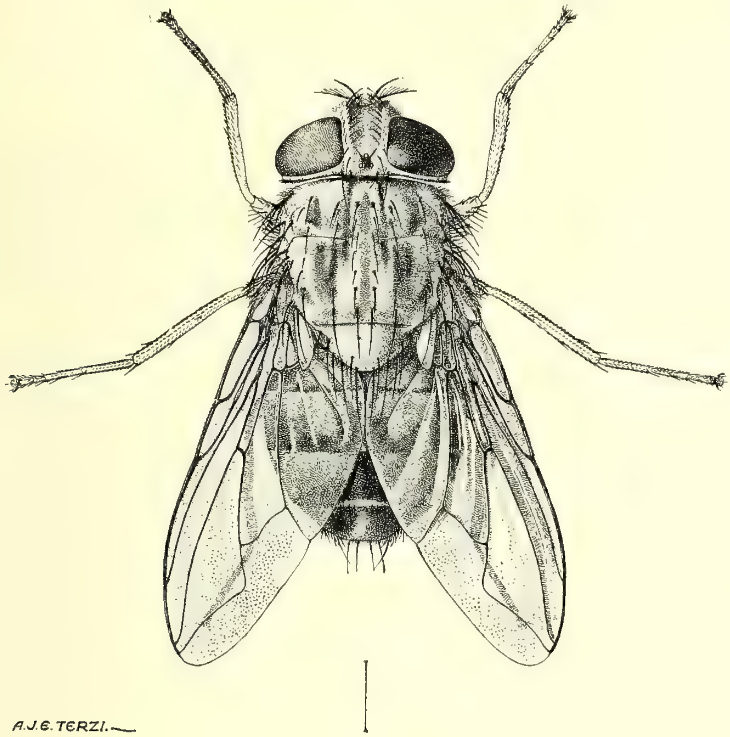

Fig. [illegible].—The Tumbu Fly (*Cordylobia anthropophaga*, Grünberg).[1]

"Care is necessary in order not to confuse *C. anthropophaga*, Grünb., with *Auchmeromyia luteola*, Fabr. (the 'Floor-Maggot Fly'), which is found in the same parts of Africa and presents a deceptive resemblance to the Tumbu fly in coloration, since it also has a pale yellow head and body, with dark markings on the thorax, and the distal half of the abdomen blackish. Without going too deeply into details, however, it may be said that the two species may be distinguished by the fact that in *A. luteola* the eyes are wide apart in both sexes, the body is narrower and more elongate, the hypopygium of the male is in the form of a conspicuous forwardly-directed hook, for which the ventral half of the penultimate segment of the abdomen serves as a sheath; and, lastly, by the fact that the second abdominal segment in the female is twice the length of the same segment in the male. The 'floor-maggot' itself is devoid of the characteristic spines described above in the case of the Tumbu-fly larva, and the posterior surface of the last segment, instead of being vertical, as in the latter, slopes backwards at an angle of 45°, and has

[1] Reproduced by kind permission of the Editor (Col. Bruce) of the *Journal of the Royal Army Medical Corps.*

around its hind margin a series of fleshy spines; the stigmatic plates on this segment, too, are extremely small and wide apart (2 mm. apart in an adult larva), while in the Tumbu fly maggot they are much larger and close together (at the nearest point separated by less than the diameter of a single stigmatic plate)."

The Tumbu Fly occurs throughout the greater part of Tropical Africa, being recorded from the West Coast, Congo State, Rhodesia, Natal and other places.

It is not definitely known in what way the host becomes infested or whether the female produces eggs or young larvæ. The larva lives in a cavity that it forms under the skin of human beings and other animals, where it causes intense irritation, and, as it develops, considerable pain. This cavity is always connected with the outside air by a small opening, by means of which the larva is enabled to breathe. When mature, the larva leaves its host, buries itself in the soil and pupates. The adult emerges in about sixteen days.

The Congo Floor Maggot

Auchmeromyia luteola, Fabricius

The adult female of *Auchmeromyia luteola* was figured and a description of its larva and an account of its habits given in the Second Report of these Laboratories.[1]

Specimens of this fly have been received from the Bahr-El-Ghazal, and it was also taken last year in the vicinity of Nasser, on the Sobat.

The Floor Maggot does not cause true myiasis, but owing to its resemblance to the preceding species it has been thought better to include it under the same heading.

IV. Insects injurious by means other than by Blood-sucking

Filth-feeding Flies

(*a*) Family, *Muscidæ*

Filth-feeding flies in Khartoum

A small series of observations on the breeding places and habits of the various species of filth-feeding flies that occur in Khartoum were carried out early in this year, and the results are of interest in that they coincide with those obtained by Smith[2] at Benares, India.

It is generally supposed that in tropical countries, human ordure, when deposited in places to which the sun has access, dries up so rapidly that flies are unable to breed in it. Smith found, however, that on the deposit becoming dry the larvæ burrowed down into the soil to a depth of from five to six inches and there pupated, eventually emerging as adults. In this case the species was *Musca entæniata*.

In Khartoum the same conditions prevail. Human ordure deposited in the open, although by the second day apparently dry, is yet sufficiently moist in the interior for maggots to be able to feed on it. As soon as it becomes thoroughly dry the maggots descend into the soil to varying depths, and, in the course of a few days, give rise to adults. A small fragment of human ordure, two days old, containing maggots about half-grown, was placed on sand in a large open glass vessel and exposed to the sun. By the following day the ordure was perfectly dry and the maggots had gone down into the sand, and, notwithstanding the intense heat to which they were exposed, they completed their life-cycle.

The sanitary regulations in Khartoum prevent filth-feeding flies becoming such a pest as they are in the native villages, where they frequently exist in almost incredible

[1] Wellcome Research Laboratories, Second Report, 1906, pp. 85–87.

[2] *Journal of the Royal Army Medical Corps*, August, 1907, p. 150.

numbers. Unless it occurs to the native to use an old empty hut as a latrine, a strip of desert about 100 yards from the village or the nearest standing crop of dura serves the purpose, and when it is remembered how many flies will breed out from a single deposit of ordure it is not surprising that one frequently finds it necessary when staying in a native village to put up a mosquito curtain if one desire peace during the heat of the day.

"Zibla" as a breeding place for flies

The so-called "Zibla" is another breeding place of flies. Zibla is a mixture of stable refuse, cow-dung, etc., which, having been allowed to ferment, is utilised for building purposes. When once it has dried it becomes quite free from maggots, but while it is being prepared many flies deposit eggs in it.

The doctors of both the Civil and Military Hospitals, as well as certain officials in the Public Works Department and other offices, very kindly collected and sent to the Laboratories numbers of flies which were making themselves a nuisance in the wards and offices, and I was thus able to ascertain which species occurred most frequently in such places. The more common of these have been sent to Mr. E. E. Austen, of the British Museum, for identification.

The two species which appear to be equally prevalent are *Musca domestica*, Linn., and one that I take to be *M. corvina*, Fabr., and it was these two that were most frequently obtained from human ordure, stable refuse and zibla.

Larvæ and pupæ of *M. domestica* and *M. corvina* were taken from the shallow trenches at the Sewage Farm, but it is improbable that flies come from there into the town owing to the distance they would have to traverse.

The two species of the genus *Pycnosoma*—*P. marginale*, Wied., and *P. putorium*, Wied.—mentioned in the Second Report of these Laboratories[1] both occur in Khartoum.

Blister Beetles

(*b*) Family, *Canthariididæ*

Plate XXX., fig. 1

During the rainy season one not infrequently awakes in the morning to find on the neck, wrists or other exposed parts a large and painful blister, such as might have been caused by scalding with boiling water. This is the work of one of the *Cantharidæ* or blister beetles, known to the natives as *Fasseea*[2]—in Kassala—*Garrāza* or by the very appropriate name of *Abu nār*—father of fire.

Khartoum blister beetles

The common species in Khartoum is the steel-blue *Epicauta sapphyrina*, Mähl (fig. 1). Another blister beetle frequently seen in Khartoum is *Mylabris nigroplantis*, Klüg. This beetle has the head and thorax black, densely clothed with greyish pubescence; elytra buff with a spot on each basal angle, a transverse row of four spots, a transverse mark resembling, when the elytra are closed, the letter M, and a similar though less complete mark near the extremities, black; antennæ and legs ochraceous; length 12 mm.

The life-cycle of the *Cantharidæ* is very complex. One species in this country is beneficial in its larval stages, feeding on the eggs of the migratory locust, *Schistocerca peregrina*.[3]

[1] Second Report, Wellcome Research Laboratories, 1906, p. 66.

[2] First Report, Wellcome Research Laboratories, 1904, p. 39.

[3] *See* page 236 of this Report.

V. Acarina

Ticks

Ixodidæ

The following species of ticks occur in the Sudan :—

Amblyomma marmoreum, taken in the Southern Sudan (Plate XXVI., figs. 1, 2).

Amblyomma variegatum,[1]* Fabr., plentiful in the southern provinces on camels, cattle, horned game, etc. It is occasionally seen in Khartoum on animals brought from the south.

Hyalomma ægyptium, Linné, generally known as the camel tick, though it also infests horses, mules, cattle, horned game, etc. It will occasionally attack man (Plate XXVI., figs. 3, 4).

udanese
cks

Boophilus australis,* chiefly on cattle.

Rhipicephalus sanguineus, Latreille, common on dogs, camels, etc.

Rhipicephalus punctatissimus, Gerstäcker, taken on cattle.

Rhipicephalus evertsi, Neumann, usually found on mules.

Rhipicephalus simus,* a cattle tick.

Margaropus annulatus, Sarg., var. *decolorata*, Koch, taken in the Upper White Nile Province. A heifer suffering from a piroplasmosis, and brought to Khartoum from the American Mission Station on the Sobat, was infested with this tick.

Argas persicus, Fischer, common throughout the northern provinces on fowls, turkeys, ducks and geese.

Ornithodoros savignyi, Auduoin, found in the northern provinces, attacking man.

Ornithodoros megnini, Ougès.

Aponomma læve,* from reptiles.

Probably many other species occur in this country, especially in the southern provinces, where cattle and game abound.

The Fowl Tick

Argas persicus, Fischer

Plate XXVI., fig. 6

The fowl tick, *Argas persicus*, occurs generally throughout the northern parts of the Sudan.

Like all the members of the family *Argasidæ*, to which it belongs, the fowl tick has no scutum on the dorsal surface, as have the common cattle ticks with which everyone is familiar. This absence of a scutum, together with its flattened appearance, cause many people to mistake it for some species of bed-bug—*Cimex*.

Life-history and habits.—The eggs are deposited in crevices in the walls of fowl-houses, cracks in the ends of perches, and other situations where the ticks are in the habit of hiding. The six-legged larva appears in about three weeks and at the first opportunity attaches itself to a fowl. A favourite place is the under surface of the wing, where young ticks may frequently be found in clusters. In a few days the larva is engorged, so, leaving its host, it secretes itself in some convenient refuge where it is sheltered from the light of day.

Having digested its meal, shed its skin, and acquired another pair of legs, the young tick, now a nymph, comes forth under cover of darkness for a second feed. This time,

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[1] Identified by Prof. Nuttall as a variety between *A. variegatum* and *A. hebræum*.

* Collected by Dr. Wenyon.

PLATE XXVI

HEREWARD DOLLMAN

ACARINA

1. *Amblyomma marmoreum*, ♂
2. *Amblyomma marmoreum*, ♀
3. *Hyalomma ægyptium*, ♂
4. *Hyalomma ægyptium*, ♀
5. *Ornithodoros savignyi*
6. *Argas persicus*

Small illustrations indicate natural sizes

however, it does not remain attached to the fowl, but, having filled itself with blood, returns to its hiding place. When this meal is digested it moults for the second time and is ready for a third feed, which it takes in the same way as it did its second.

After some weeks spent in retirement the tick sheds its skin once more and becomes an adult. Henceforth it spends most of its time in concealment, occasionally emerging from its retreat by night to obtain blood.

Under favourable conditions, the development from egg to adult may be completed in from two to three months.

Fowl ticks and disease

A fowl attacked by ticks suffers in several ways. The irritation caused by the bites renders the bird restless, while the amount of blood lost is frequently sufficient to cause its death. This is especially the case with chicks and young growing fowls. A third and perhaps the most important way in which the fowl tick does harm is by transmitting an often fatal disease known as *Spirochætosis.*[1] It will be seen, therefore, that if fowls are to be successfully reared in this country, it is very necessary to take every precaution to keep them free from these parasites.

Argas persicus commonly infests fowls, turkeys, ducks and geese. In Persia, it is said to attack man.

Preventions and remedies.—Unfortunately, the mud structures that so frequently serve the purpose of fowl-houses in this country are in every way suited for harbouring ticks.

Preventive measures

The walls of a fowl-house should contain no cracks or crevices in which ticks can hide, and the same applies to the perches, nest boxes and other fittings. A good plan is to have the perches not connected with the walls, but supported by standards which have as their bases pans containing oil, or water with a film of oil on it. Another plan is to suspend the perches from the roof by wires, though this is hardly so effective. Various other devices to prevent ticks from gaining access to the fowls by night are in use in South Africa,[2] where *Argas persicus* abounds.

Remedies

If a fowl-house and its inmates are found to be infested, the following steps should be taken: The birds should be removed to some place believed to be free from ticks and to which they have not had access before. It is well when doing this to examine the birds for larval ticks and to treat any that are so found with sweet oil. If the fowl-house is a good solid structure, it may be thought advisable to disinfect it, but otherwise it is best to pull it down and as far as possible burn it. Hot coal tar is said to be very effective for treating the walls. All wooden fittings—*e.g.* perches, nest boxes, etc.—should be burnt. If there is a flooring of bricks, it should be treated in the same way as the walls, but if it is merely a mud floor, the top layer should be removed and burnt. Ticks will also shelter under the bark of trees, in cracks in fences, and similar places, so these must not be forgotten when cleansing the run. Having thoroughly rid the house and run of ticks and made certain that there are no larvæ on the fowls, they may be brought back. Continual attention will be necessary to prevent them becoming re-infested. If there be any sign of re-infestation, the nest boxes and any places suspected of harbouring ticks should be treated with paraffin and the birds themselves searched for larvæ.

Before new fowls are introduced into a fowl-house believed to be free from ticks, they should be carefully examined for larval forms, and a safe measure is to isolate them for a week to allow any larvæ that may have been overlooked to drop off. If any ticks are found on them, the boxes or crates in which they arrived should be burnt.

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[1] *See* pages 37–58 of this Report.

[2] Cape of Good Hope *Agricultural Journal,* September, 1903.

The Human Tick
Ornithodoros savignyi, Auduoin

Plate XXVI., fig. 5

The human tick, *Ornithodoros savignyi*, has been taken at Fatashia—twenty-two miles west of Omdurman—by Mr. N. Wilkinson, and at a well situated about twelve miles north-east of Khartoum North. A single specimen was among some insects given me by Dr. Crispin, collected in the neighbourhood of Port Sudan.

The human tick

Normally this tick feeds by night, but probably those that live by wells get many of their meals from travellers resting during the heat of the day, for they can then be seen actively running about in search of a host. If touched they at once feign death.

The life-history of *O. savignyi* has been described by Christophers.[1]

The eggs are deposited in a mass on the soil, and hatch in about a week. The six-legged larvæ, unlike those of cattle ticks, are inactive, but moult after three or four days and become active eight-legged nymphs. They are then ready for a meal.

In many respects the habits of the human tick resemble those of the fowl tick, *Argas persicus*.

Scaly Leg
Sarcoptes mutans, Rob.

The condition among fowls known as *scaly leg* is due to a small mite, *Sarcoptes mutans*, Rob. It is common in the northern parts of the Sudan, but appears to attract little attention. A number of the fowls exhibited at the Berber Province Agricultural Show this year were suffering from this disease.

Turkeys and pigeons are also liable to the attack of this parasite.

Scaly leg in fowls

The mite lives under the scales covering the anterior parts of the legs and toes of fowls, where it sets up acute irritation. A quantity of white powdery matter forms under the scales, lifting them up, and the leg assumes a rugged unhealthy appearance. The symptoms become more and more pronounced as the number of mites living under the scales increases, lameness ensues, and the fowl, instead of spending the day actively searching for food, mopes in solitude. Its health naturally suffers from this, and in time it probably falls a victim to some comparatively trivial complaint which, were it in robust health, it would be able to withstand.

Treatment.—Diseased fowls should be isolated and the perches they have been using either disinfected or destroyed. The treatment usually recommended is that of soaking the affected legs in warm water, removing the encrusted scales and painting with carbolic acid ointment. Another method in vogue among poultry keepers in England and said to be effective is to apply paraffin liberally to the diseased parts, after having well soaked the legs in hot water—as hot as can be borne by the hand.

Animals injurious to Farm and Garden Crops

I. Animals injurious to Corn

The Dura Stem Borer
Sesamia cretica

Plate XXVII., figs. 1, 3, 6

Pest of millet and maize

This is one of the worst pests from which dura and maize (dura shami) suffer in this country. Sugar cane is also attacked, but to a less extent.

[1] Christophers, "Anatomy and Histology of Ticks." *Scientific Memoirs by Officers of the Medical and Sanitary Departments of the Government of India.* No. 23.

PLATE XXVII

C. M. Beard

1. *Sesamia cretica*, adult
2. *Gonitis involuta*, Walk., adult
3. *Sesamia cretica*, larva
4. Maize cob damaged by larvæ of *Sesamia cretica*
5. *Earias insulana*, adult
6. *Sesamia cretica*, pupa
7. *Remegia frugalis*, Fab., larva
8. *Tarache tropica*, adult
9. *Remegia frugalis*, Fab., adult ♂
10. *Remegia frugalis*, Fab., adult ♀

All illustrations are natural size

Egg.—The egg is white, circular when viewed from above, flattened and radially striated.

Diameter, about 6 mm.

Larva (fig. 3).—The caterpillar varies in colour from pinkish or yellowish to dead white. Head brown, spiracles black.

Length, 25–30 mm.

Pupa (fig. 6).—The pupa is light chestnut in colour, with the intersegmental spaces on the abdomen yellowish.

Length, 15–18 mm.

Adult (fig. 1).—A stout-bodied, creamy-coloured moth, with a wing expanse of about 30 mm.

Thorax, abdomen, and fore-wings creamy. Hind-wings, silvery-white. Fore-wings sometimes bear faint brownish markings.

Life-history and habits.—The eggs are deposited, frequently in batches of from three to five, between the sheathing leaf and the stem. On hatching, the young larva eats its way into the stem, and tunnels both upwards and downwards. A young plant so attacked soon dies, and the larva is then compelled to migrate to another plant in order to complete its development.

When full-fed, it pupates in a loose cocoon composed of silk, chips and frass, usually within the burrow, or between the sheathing leaf and the stem. Occasionally a caterpillar will pupate within an earthen cell in the soil.

The life-cycle may be completed in about six weeks.

Where food plants are available, this pest breeds continually throughout the year.

Effects on the crop.—While the crop is young, numbers of the plants are killed by the borers. Later on in the season, they become strong enough to withstand the attack, though their growth is necessarily impaired.

When the heads of corn are forming, many larvæ betake themselves to them, and do considerable damage by gnawing the grain and fouling it with their excreta. In the case of dura shami, the cob becomes stunted and deformed and bears but few grains (fig. 4). A head of dura, however, being of a different construction, suffers more from fouling—the larva takes up its position between the head and its sheathing leaf, moisture collects, moulds are enabled to grow, and frequently that portion of the head becomes nothing but a filthy mass.

It is no uncommon occurrence to find several larvæ collected together in a single head of corn.

Probably the death of a few plants at the beginning of the season has little effect on the ultimate yield of corn per feddan, but, by weakening the older plants and damaging the developing corn heads, the borers are responsible for a very real loss to the farmer.

Preventions and remedies.—When there is no crop on the ground for this pest to attack, it passes the time either as the moth, or as the mature larva, or the pupa resting in the dead stalks. To keep it in check, therefore, it will be necessary to adopt several measures.

When the crop is harvested, collect and burn all refuse, such as stubble.

When feeding the "gash" (or straw) to stock, ensure that it is all either eaten, or so trampled upon that any larvæ or pupæ contained in it must be destroyed.

Before sowing the main crop, plant a few "hods" of land to either dura or dura shami, to act as a trap crop. Moths will be attracted to lay their eggs on this, and when found to be infested it should be reaped, and either burnt or fed to stock. Dura shami would probably be the more suitable for this purpose, as there is a danger of stock suffering from hydrocyanic acid poisoning if green immature dura is used as forage.

Lastly, children might be employed to collect the borers while the crop is still young Infested plants are easily detected by the central growing shoot wilting and turning brown.

It is, perhaps, hardly necessary to point out that to be effective these measures must be carried out by all the farmers in a district. It would be of very little use for a man to burn his stubble and plant trap crops if his neighbours on either side allowed the borers to breed with impunity.

The White Nile Army Worm

Remegia frugalis, Fab.

Plate XXVII., figs. 7, 9, 10

Forage pest

The larva of *Remegia frugalis* has been given the above local name owing to the belief among the natives that it is brought by the rising White Nile.

Two outbreaks of this pest occurred in 1906—on the Government Forage Farm at Khartoum and on the Cavalry Forage Farm at Shendi. In the latter place an area of ten feddans (acres) of garowi grass (*Andropogon halepensis*) was reported to have been stripped in a single night.

It was only noticed feeding on garowi and dura, but probably it would not hesitate to attack wheat, barley and other cereals.

Larva (fig. 7).—A yellowish-brown to dark brown caterpillar, varying from 40 mm. to 55 mm. in length.

Head, light brown, with a paler median stripe. Body with two dark stripes on the dorsal surface, leaving a pale median dorsal stripe. Spiracles dark. A yellow sub-spiracular line, and a median ventral longitudinal dark brown line. On the seventh and usually on the eighth segments are two black longitudinal marks, situated on the outer edge of the sub-dorsal stripes. At the junctions of the fourth and fifth and of the fifth and sixth segments, on the dorsal surface, are black transverse marks bearing small white spots. These marks are very conspicuous when the larva rests with its body curved, but are frequently invisible when the body is straight.

The prolegs are situated on the eighth, ninth and anal segments.

Both light and dark forms of the larvæ occur.

Pupa.—Dark brown, covered with a purplish bloom and 18–19 mm. in length.

Adult (figs. 9, 10).—A brown moth, about 17 mm. in length, and with a wing expanse of 40–45 mm.

On the fore-wing is a slanting transverse dark line, between which and the margin is a row of seven or eight dark spots.

Hind-wing similar to the fore-wing, but the markings fainter and the row of spots replaced by a dusky shaded line. Sometimes there is a reniform mark on the median area of the fore-wing.

The male differs from the female in having the hind-legs densely feathered and in having situated at the base of the fore-leg a tuft of long hair. This is unnoticeable until the fore-leg is extended, when it springs out on either side.

When the moth is at rest the wings are laid flat, forming a triangle.

Life-history and habits.—The larvæ were first observed when about half-grown, feeding on the foliage of dura. The leaves were stripped to the mid-rib, but, as the larvæ commenced with the lower leaves, it was not until a considerable amount of damage had been done that the attack became very noticeable.

When alarmed, the larva either clings to the leaf with its prolegs and arches its body, remaining in this position for some time, or drops to the ground and feigns death.

At Shendi, having exhausted their food supply, the caterpillars began to migrate in the fashion of the well-known army worm—*Leucania unipuncta*.

When full-fed, the larva spins up a cocoon composed of fragments of leaves, and sometimes frass. Pupal cases may frequently be found on the ends of leaves.

The adult emerges in seven to eight days.

The moths bred out in the laboratory all died without ovipositing.

Preventions and remedies.—Hand-pick the larvæ—children can be employed to do this at a price per oke or litre.

Where they are migrating, dig a trench, with perpendicular sides, across their line of march. In this trench, at intervals of a few feet, dig deep holes. The larvæ, falling into the trench, and being unable to climb out readily, will crawl along the bottom, seeking an exit, and so drop into the holes, where they can easily be destroyed.

Cockchafer attacking Dukhn

Rhinhyptia, sp.

Specimens of a small cockchafer were sent from Kordofan during December, 1907, with notes that it was feeding on dukhn. It could not be identified with any of the chafers at the British Museum, and is probably a new species. A pest of dukhn

Most of the chafers spend their larval stages in the soil, feeding on the roots of plants, and may take up to five years to complete their development.

Preventions and remedies.—The adults of the common European cockchafer—*Melolanthus vulgaris*—usually spend the day clinging to the leaves and twigs of trees, when, by beating or shaking the branches, large numbers can be induced to fall on to cloths spread below to receive them. Probably this method of collecting the beetles could be adopted in Kordofan.

The Dura Plant Bug

Lygæus militaris, Fab.

This insect was figured in the Second Report of these Laboratories. The so-called "Dura bug"

Although known as the "Dura bug," I have rarely seen it occurring in sufficient numbers on dura to constitute a pest. It feeds on a variety of plants and appears to be universal in its distribution throughout the Sudan.

Preventions and remedies.—Where the bugs are noticed in large numbers attacking dura or other crops, children might be employed to hand-pick them.

The Andata Bug

Agonoscelus puberula, Stal.

Plate XXVIII., fig. 11

A serious outbreak of this pest occurred in the Blue Nile Province during the autumn of 1906. The bugs swarmed on the dura, sucking the juices from the developing heads of corn, and in some districts completely ruining the crop. A certain number were observed during the following summer attacking young dates.

They were rarely seen far from the river.

A similar plague of these insects is recorded to have occurred in the same district some thirty-five years previously, when they were responsible for a large amount of damage to the dura crop. In the following season, however, very few were noticed.

A serious dura pest

I have seen this bug feeding on grasses in the Upper White Nile Province in the neighbourhood of Taufikia, and near Nasser on the Sobat.

The following is a translation from the Latin of Stal's description of this insect, which he records from Caffraria and South Africa.

"Pale straw coloured. Scutellum more densely punctured towards the base. Fore-wings sometimes slightly ferruginous. Antennæ, with the exception of the inner side of the first joint, three or four small spots on the ventral surface of the thorax, small discoidal spots arranged in groups of four on the ventral surface of the abdomen, marginal spots on the basal angles and on the apices of the segments—other than the spiracles—a spot on the basal half of the femur and the tarsi in part, black. Lateral margins of the anterior part of the thorax, a small basal area of the scutellum, and the apex of the scutellum, pale and but slightly punctured.

"Hind-wings very slightly infuscated, apices clear, membrane glassy, interior basal angle fuscous. Veins generally slightly infuscate.

"Second and third joints of antennæ subequal. Rostrum extending to the middle of the venter.

"*Length*, 7–8½ mm. *Breadth*, 4–4½ mm."

It is difficult to account for the sudden increases in numbers of an insect which usually is not sufficiently common to justify its being ranked as a pest. Certain climatic and other conditions are presumably necessary to enable it to multiply to any very great extent, and it is fortunate that these conditions do not more often obtain.

The asal fly

The Asal Fly

Aphis sorghi, Theob.

This destructive aphis has recently been recorded from Northern Nigeria, and also from South Africa, where it attacks a species of sorghum known as Kaffir corn.[1]

In the Sudan it appears to confine its attentions mainly to the dura grown on the river banks—*Seluka* crops—the rain crops in the desert being as a rule free from this pest.

In the earlier stages of an attack of asal fly, the aphides may be found in small colonies on the undersides of the leaves. Each colony usually consists of a winged viviparous female and numbers of larvæ and apterous viviparous females. These latter produce young parthenogenetically.

Like the other members of the family *Aphidæ*, the asal fly increases in numbers with extraordinary rapidity, and soon the undersides of nearly all the leaves of the infested plants are covered with these tiny insects. Honeydew is secreted in vast quantities, and this, falling on to the leaves below, chokes up the stomata and so prevents respiration.

Large numbers of flies, bees, ants and other insects are attracted by the honeydew, and by their presence the infestation of a few isolated plants among the crop can be detected.

The attack is not usually noticed until it has become general, and by that time the crop has been more or less ruined. It is then that the asal fly apparently leaves the dura and, in all probability, migrates to some other plant.

[1] Theobald, F. V., *Report on Economic Zoology*, for year ending April 1st, 1907, p. 149.

PLATE XXVIII

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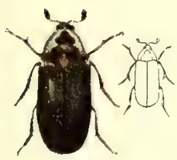

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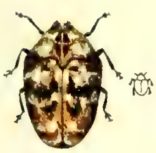

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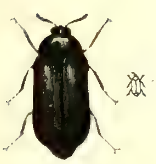

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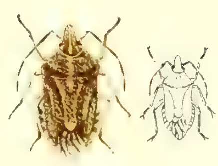


11

C M BEARD

1. The Date Scale, *Parlatoria (Websteriella) blanchardi*. Sarg. Tozz. on date
2. The Date Scale ♂ puparium
3. The Date Scale ♀ puparium
4. *Dermestes vulpinus*, adult
5. *Dermestes vulpinus*, larva
6. The Date Scale on date palm leaf
7. *Anthrenus vorax*, adult
8. *Anthrenus vorax*, larva. (This specimen had unfortunately been denuded of hair)
9. *Attogenus*, sp., adult
10. *Attogenus*, sp., larva
11. *Agonoscelus puberula*, Stal.

Illustrations are natural size unless otherwise indicated

During the last week of March, 1907, asal fly was reported from the district between Shendi and Gebel Umali. By the time I arrived there most of the infested dura had been reaped, but at one place some was still standing. The plants were alive but literally smothered with honeydew, and even the ground underneath them was caked with it. The fly itself, however, had left the dura, and a careful search failed to reveal any aphis either above or below ground on any plants growing in the vicinity.

Natural enemies.—Chief among the natural enemies of the asal fly are several species of lady-bird beetles, which, in both their larval and adult stages, feed freely on the aphides and the larva of an undetermined species of *Syrphus* fly. These and other predaceous insects do a certain amount of good, and sometimes completely stamp out an attack while still in its early stages. On several occasions this has been the case on the dura grown in the Gordon College garden, where there are always considerable numbers of lady-bird beetles and *Syrphus* flies to be found. Usually, however, these beneficial insects are not sufficiently plentiful when the asal fly makes its appearance to do any appreciable good, and by the time their numbers have increased the damage has been done. Natural enemies of the aphis

The injury suffered by the crop is probably due more to the smothering of the leaves with honeydew than to the actual loss of sap sucked out by the insects.

Much remains to be learned of the life-history of this pest. As above stated, it probably, on leaving the dura, migrates to some other plant, where, possibly in an altered form, it spends that part of the year when it is not to be found on the dura.

Another species of aphis attacks dura but has not as yet been seen occurring in sufficient numbers to be worthy of the rank of a pest. It is usually found in the growing point of the plant or between the sheathing leaf and the head of corn.

A Millipede attacking Dukhn

Julus, sp.

A large millipede, locally known as *Surrfa*, is a pest of some importance in parts of Kordofan, where it is said to attack the roots of dukhn.

It is about 11 cm. in length and in colour dark brown, with the bases of the somites paler.

The millipedes are not true insects, but belong to the group known as *Myriapoda*. The *Myriapoda* are divided into five orders—the two more important ones being the *Chilognatha* or millipedes and the *Chilopoda* or centipedes. The latter are usually beneficial to man, being carnivorous in their habits, and so helping to keep in check some of the noxious insects. They possess only one pair of legs to each body ring and can thus be distinguished from the millipedes, which are provided with two pairs to each segment. Millipedes

Some of the larger centipedes are capable of inflicting a very poisonous bite when incautiously handled.

The millipedes, known in England as *false wire worms*, are mainly vegetarians, feeding both on decaying organic matter and living plants. They have also been recorded to devour slugs, snails, etc. They are incapable of biting when handled, but some of them can emit a very evil smelling liquid.

Several species of millipedes occur in England as farm pests, attacking mangolds, beets, potatoes, strawberries, etc.

The following is a brief outline of the life-history of *Julus terrestris*, one of the more common of the millipedes found in England.

The female deposits within a spherical nest, composed of pellets of mud cemented together with saliva, from 60 to 100 eggs. The nest is then sealed up with mud and left. The young millipedes emerge in about twelve days and are provided with only three pairs of legs. The other legs appear in batches of five at a time, the addition of legs and segments taking place between the end segment and the penultimate.

Preventions and remedies.—During the rains, large numbers of these millipedes can be seen crawling about on the ground. They can then be collected and destroyed.

Baits have been found to be very efficient in helping to keep English species in check. Scooped out mangolds or beets are buried just under the soil, and the millipedes, which are attracted to feed on them, collected at intervals.

Another method is to soak these baits in a liquid containing arsenic—millipedes readily feed on them and are poisoned.

Where, as in Kordofan, mangolds and beets are not available, other baits can be substituted.

These measures should be carried out *before* the crop is sown, when there is little else in the soil for the millipedes to eat.

II. Animals injurious to Cotton

The Egyptian Cotton Boll-worm

Earias insulana

Plate XXVII., fig. 5

Cotton pests

This pest is very common in the Sudan, and is responsible for a considerable yearly loss to cotton growers.

It is found throughout Africa, and is also recorded from Mauritius, Baluchistan, North and South India, Burma, Siam, and Australia.

In Egypt

In Egypt it is said to be the cause of an annual loss of nearly £1,000,000.[1]

Life-history and habits.—The eggs are deposited, usually singly, on almost any part of the plant, the most common position being on the terminal buds. The larva, on hatching, may either eat its way through the terminal bud and tunnel down the stem for a short distance, or straightway attack a flower bud or boll. When full-fed it leaves the boll and pupates in a white to brownish boat-shaped silken cocoon, attached to some part of the plant—frequently to the involucral bracts of the damaged boll. The adults emerge in from one to a little over two months.

Where food plants are available this pest appears to breed continuously throughout the year.

Egg.—In colour, when first laid, the egg is pale turquoise blue with a greenish tinge. In shape it may be said to resemble a poppy-seed head.

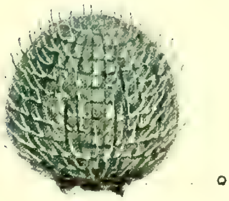
Larva.—A somewhat hunched caterpillar, 15–16 mm. in length. In colour it varies from light or reddish-brown to dull green, with yellowish markings. The body is ornamented with a number of fleshy tubercles or spikes.

Pupa.—The pupa is yellowish brown, often with a greenish tinge. Length 9–11·5 mm.

Adult.—The moth is exceedingly variable in colour, the most common form having the head, thorax and fore-wings bright green, the hind-wings semi-diaphanous white with fuscous margins, and the abdomen silvery-grey. The fore-wings usually bear three dark

[1] Willcocks, *Year-book of Khedival Agricultural Society*, 1905, p. 63.

PLATE XXIX



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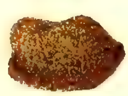

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C. M. Beard

The Sudan Cotton Boll Worm, *Diparopsis castanea*, Hampson

1. Egg
2. Larva
3. Adult
4. Pupa
5. Pupal cell

Illustrations are natural size unless otherwise indicated

wavy transverse lines, which form, when the moth is at rest and the wings closed, three **W**-shaped letters. Another form frequently seen resembles the above except that the green scales are replaced by bright yellow ones.

A third form sometimes noticed is figured on Plate XXVII., fig. 5.

Body length, 8–10 mm. Wing expanse from 22 mm.

Food plants.—The Egyptian boll-worm has been found attacking most of the plants belonging to the Nat. Order *Malvaceæ* that occur in this country, including bamia and kirkidi. The boll-worms

Preventions and remedies.—No definite remedy can be suggested for this pest, but it can, to a large extent, be kept in check by clean cultivation.

All stray cotton and other plants belonging to the Nat. Order *Malvaceæ* should be uprooted and destroyed.

The remnants of an infested crop should, when possible, be burnt, and should certainly never be allowed to remain in the field after the crop has been gathered.

Where sufficient labour is available infested shoots and bolls might be collected and burnt while the plants are still young.

Finally, the use of trap crops might be resorted to—*i.e.* small areas of land sown with cotton at such times that the plants will be in bloom, just before the main crop comes up and just after it is gathered. Many moths will be attracted to lay their eggs on these plants, which should then be collected and burnt.

For a more detailed account of the habits, etc., of the Egyptian boll-worm the reader is referred to the *Year-book for* 1905 *of the Khedival Agricultural Society*, Cairo.

The Sudan Cotton Boll-worm

Diparopsis castanea, Hampson

Plate XXIX

This boll-worm was first observed attacking cotton growing in the Laboratory garden in 1906. It has since been seen on the Government Experimental Farm at Halfaya, and a single larva was taken in 1907 at Kittiab. It is probably an introduced species, but has been given the above name to distinguish it from the Egyptian boll-worm, *Earias insulana*.

Larvæ were reared in the Laboratories from eggs collected in the garden during 1906, but, owing to my departure from Khartoum before the adults emerged from the pupæ, no perfect moths were obtained.

The accompanying illustration (fig. 3) is taken from a specimen kindly given me by Mr. Willcocks, Entomologist to the Khedival Agricultural Society, Cairo, who had had a number sent him from Uganda.

Other countries from which it is recorded are Beira and Delagoa Bay.

Life-history and habits.—The eggs are deposited singly, either on the stem, leaves or involucre, the usual position being the young terminal leaves. The larva, on hatching, bores into the nearest flower-bud or boll, which it hollows out before deserting it in favour of another. It may destroy several bolls before attaining maturity.

When full-fed it drops or crawls to the ground and, burrowing into the soil, pupates within a strong cell (fig. 5) composed of particles of earth cemented together with saliva.

There are probably two or three broods during the winter.

The summer was passed, by the few kept under observation, in the pupal stage. Only one, however, lived until the following winter, when it died without completing its life-cycle.

Egg (fig. 1).—When first laid the egg is bright turquoise blue in colour, but, prior to hatching, it assumes a purplish to brownish tinge. In shape it is spherical with a more or less flattened base. Diameter ·75–·85 mm.

The sculpturings on the shell are as follows: a small depression round the microphyle is surrounded by a slightly raised ridge. Similar concentric ridges succeed each other over the whole surface of the egg. Cutting these are upright ridges, converging towards the centre and thus enclosing little depressions. Within these depressions the shell is faintly sculptured. A number of the upright ridges end before reaching the top. At each point where the upright and the concentric ridges intersect, a spine arises, slightly clubbed.

Larva (fig. 2).—A thick-set apple-green caterpillar with rosy-red markings. Length of mature larva, 25–30 mm.

In clearly marked specimens the following characteristics can be determined:—

Head, chestnut-brown. Thoracic shield brown with a greenish tinge, and cut by a pale median line.

A median stripe on each segment forms an interrupted median dorsal line. On either side of the median stripe on each segment is a similar stripe sloping downwards and backwards. Spiracles, black. On either side of the first segments, anteriorly placed to the spiracles, is a black dot, from the centre of which arises a black hair. On the second segment is a transverse row of twelve black dots, each surrounded by a rosy ring and bearing a hair. On either side of the sloping stripes on each segment is a black dot, bearing a hair. Immediately above, below and posterior to each spiracle, is a black dot, surrounded by a rosy ring and bearing a hair. A row of similar dots is situated immediately above the setting on of the legs. An anal shield of greenish brown extends slightly over the margin of the twelfth segment. On young larvæ the anal shield is very prominent and dark in colour, as is often the thoracic shield.

Venter, apple-green, with the exception of the fourth and fifth segments, which are ringed with red.

These markings are subject to considerable variations.

Pupa (fig. 4).—Light yellowish chestnut-brown, sometimes with a greenish tinge. Length, 13–14 mm.

Thorax, rather lighter in colour than the abdomen. A darkish median dorsal line starts on the crest of the thorax and extends to the tip of the abdomen. Spiracles and eyes, reddish to dark brown.

Adult (fig. 3).—A greenish-pink moth with a length of 12–14 mm., and a wing expanse of 30–32 mm. Described from a faded and damaged specimen.

Head and thorax, reddish green. Fore-wings, dull pink with a green triangular mark at the base and a broad green transverse stripe towards the margin. Fringe, greenish.

Hind-wings, silvery white, suffused with pink towards the margin.

Abdomen, silvery white.

Preventions and remedies.—Until its life-history and habits are better known, the only remedy that can be suggested for this pest is that of hand-picking the larvæ early in the season. Over small areas it might possibly prove practicable to collect the eggs, as they are very easily seen when first laid.

Cotton Flea Beetles

Nisotra uniformis, Jac., and *Aphtona*, sp.

Plate XXX., figs. 4, 5

Other cotton pests

Two species of flea beetles have been observed attacking cotton—*Nisotra uniformis*, Jac. (fig. 4) and an undetermined species of *Aphtona* (fig. 5).

PLATE XXX

C. M. Beart

1. *Epicauta sapphyrina*, Mahl
2. *Pachnoda savignyi*, G. and P.
3. *Stalagmosoma cynanche*, G. and P.
4. *Nisotra uniformis*, Jac.
5. *Aphtona*, sp.
6. *Aspidomorpha chlorotica*, Oliv.
7. A Buprestid
8. *Aspidomorpha mutabilis*, Klug.
9. Locust-egg eating larva of one of the *Cantharidæ*
10. *Sinoxylon senegalense*
11. Piece of wood damaged by *Sinoxylon senegalense*

Illustrations are natural size unless otherwise indicated

The latter is about 3 mm. in length and bluey-black in colour—not unlike the Hop flea, *Haltica concinna*, Curtis. The former is about 4 mm. in length and of a uniform chestnut-brown colour, with the terminal joints of the antennæ darker.

Of the two, *Nisotra uniformis* is the more common. During the winter 1907–8 it was twice received at the laboratories with complaints of the damage that it was doing.

The adults of both species feed freely on the leaves of cotton and bamia.

Preventions and remedies.—As these beetles do not usually occur in very great numbers until the cotton crop is nearly ready for gathering, it is unlikely that they are the cause of much loss to the farmer. When thought desirable, however, they could probably be poisoned by means of arsenical sprays—*e.g.* arsenate of lead—or driven away by the use of paraffin emulsion spray.

The preventive measures recommended for the Egyptian boll-worm would also have the effect of lessening the number of flea beetles.

The Cotton Root and Stem Borer

During April, 1907, my attention was called to some cotton at Taragma that was dying from some unknown cause. On investigation the roots and lower parts of the stems of the plants were found to be attacked by the larvæ of one of the wood-boring beetles, probably a *Buprestid.* These larvæ were tunnelling in the wood either immediately above or below the ground level.

An attempt made to breed out the adults was unsuccessful.

During the winter 1907–8, while I was away from Khartoum, infested cotton plants were twice sent to the laboratories with requests for suggestions as to remedial measures—by Mr. Neville from Zeidab, and by Mr. Durant from the Government Experimental Farm at Halfaya.

This beetle is distinct from the American Cotton Stalk-borer, *Ataxia crypta*, Say.

Preventions and remedies.—For the present, the only method that can be suggested for dealing with this pest is to collect and burn all the infested cotton plants while the larvæ are still in them.

The Egyptian Cotton Stainer

Oxycarenus hyalinipennis, Costa

This is the little bug that is frequently seen in numbers in the cotton bolls towards the end of the season.

While the plants are young they feed by puncturing the bolls with their probosces and sucking the sap; later when the bolls open they enter and attack the seeds.

They also cause considerable damage by fouling the fibre with their excrement.

The adults are blackish, the larvæ bright red.

In common with the majority of the members of the Nat. Order *Hemiptera*, the cotton stainer has the power of emitting a peculiarly offensive smell. This smell is particularly noticeable if one of the insects is crushed.

Preventions and remedies.—During the season when no cotton is growing these insects collect on the refuse of the crop. They can then be destroyed either by the application of hot water or by burning.

The Cotton Aphis

Aphis malvæ, Koch

This aphis has been noticed several times on cotton, but never in sufficient numbers to cause appreciable damage.

In Egypt it, or an allied species, is a pest of some importance.

Cucurb pests

III. Animals injurious to Cucurbs

The Melon Lady-bird

Epilachna chrysomelina, Fab.

Plate XXXI

This plant-feeding lady-bird is met with in many parts of the Sudan.

During 1907, it was responsible for a considerable amount of damage to melons and cucumbers at Khartoum and at Dueim.

The *egg* (fig. 2) is elliptical in shape and orange in colour. The shell is faintly sculptured, and on the end attached to the leaf are several small tubercles.

Length, 1·75–2 mm.

The *larva* (fig. 4) is pale orange in colour, and has, on the dorsal surface, six longitudinal rows of branched tubercles, the branches terminating in spines and sometimes dark in colour.

Length, about 7 mm.

The *adult* (fig. 1) is orange to orange-red in colour, though occasionally very dark specimens can be found. The elytra bear twelve black spots ringed with pale orange and arranged in three transverse rows of four. The whole beetle is covered with a pale pubescence.

Length, 7–8 mm.

Life-history and habits.—The eggs are deposited in batches, varying in number from five to twenty-five, usually on the under-surface of the leaf.

The larvæ feed on the epidermis, at first clustered together, but later scattered over the plant.

When full-fed they pupate attached to the leaf by their anal end.

The life-cycle occupies about 28 days.

This pest attacks the foliage of cucurbs in both its larval and adult stages.

Preventions and remedies.—Hand-picking the leaves bearing the egg clusters or young larvæ would probably prove the easiest way of keeping this pest in check.

All refuse in which the beetles collect should be burned.

The Melon Weevil

Baridius, sp.

Melon pests

The larva of this weevil was found infesting sweet melons growing on the Government Experimental Farm at Halfaya during March of this year. Since then it has been sent to the laboratories in sweet melons that had been bought in the Khartoum market.

Larva.—A yellowish-white, transversely wrinkled, curved, footless grub with a chestnut-brown head.

Length, about 9 mm.

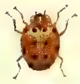
Pupa.—Yellowish-white.

Adult.—An active black weevil with a long proboscis. The whole surface densely punctured. Elytra longitudinally striated.

Length, 4·5–6·5 mm.

Life-history.—The larvæ were present in large numbers within the melons, feeding on both the pulp and seeds. When mature, they pupated in cells composed of powdered seed cemented with saliva and grouped together in clusters within the dried husk of the melon. The adults emerged in eleven to twelve days.

PLATE XXXI



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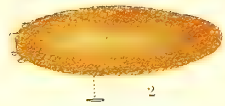

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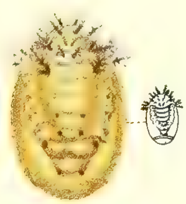

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C. M. BEARD

THE MELON LADY-BIRD, *Epilachna chrysomelina*, FAB.

1. Adult
2. Egg
3. Underside of melon leaf showing egg clusters and pupæ *in situ*
4. Larva
5. Pupa

Illustrations are natural size unless otherwise indicated

Preventions and remedies.—The infested melons should be collected and burnt. On no account should they be thrown into the river, as a large proportion of them would float down stream and be a source of infection to other cultivations.

THE MELON STEM BORER

During March of this year Mr. Hewison, of the Agricultural and Lands Department, called my attention to some grubs that were tunnelling in the stems of sweet melons growing on the Government Experimental Farm at Halfaya. Five specimens were brought to the laboratories, but at the time of writing only one has reached the adult stage. They proved to be the larvæ of a longicorn beetle.

This pest has also been recorded from Rufaa on the Blue Nile.

Larva.—A yellow transversely-wrinkled footless grub with a brown head and a few short hairs scattered over the body. Thoracic shield white, anteriorly marked with brown.

Length, about 15 mm.

Adult.—Dark brown, densely clothed with pubescence yellowish-brown in colour with the exception of two broad transverse white bars on the elytra.

Length, 9–12½ mm.

Life-history.—The larva tunnels in the stem just above the ground level. The single specimen bred out under observation pupated without forming a cocoon, lying naked on the surface of the soil. The adult emerged in six days.

THE MELON FRUIT FLY

Dacus, sp.

This pest, which appears to attack melons wherever they are grown in the Sudan, was described and figured in the Second Report, Wellcome Research Laboratories. It is responsible for a considerable loss to cultivators in the course of the year.

The adult is a pretty fly 7–10 mm. in length, and with a wing expanse of 12–14 mm. It is wasp-like in appearance and in colour ashy-grey to brown with yellow markings. It may frequently be seen sunning itself on the melon leaves, but, being shy in habits, would hardly be noticed unless looked for.

The larva is 10–12 mm. in length and creamy white in colour. It is a typical "maggot" in shape, being bluntly truncated posteriorly, and tapering to a point at the head end.

The puparium is of the same colour as the larva and 6–7 mm. in length.

Life-history and habits.—With her sharp ovipositor the female fly places her eggs beneath the rind of the developing melon or cucumber. The larvæ, on hatching, tunnel about in the fruit, causing rapid decomposition to take place.

When cucumbers are attacked the larvæ first work up the centre, among the seeds, before tunnelling in the walls of the fruit.

When mature they leave the melon or cucumber and pupate just below the surface of the soil.

The adults emerge in from nine to ten days.

Where food plants are available this pest breeds continuously throughout the year.

Food plants.—The melon fruit fly will attack water melons (*batikh*), sweet melons (*shammam*), cucumbers (*khiar*), and probably many other members of the same family.

Preventions and remedies.—The custom in vogue at present is to leave the infested melons to rot on the ground, thus giving the larvæ every chance of completing their life-cycle. This pest should be readily controlled by collecting and destroying every melon and cucumber that shows signs of attack. The most effective methods of destroying them are either to burn them or bury them deeply beneath at least eighteen inches of tightly rammed soil.

The Melon Plant Bug

Aspongopus viduatus, Fab.

This well-known pest of melons was figured in the First Report of these Laboratories. It is exceedingly common, in fact one rarely sees melons or cucumbers uninfested.

It is too well known to need description.

Preventions and remedies.—Collect and burn the refuse of diseased crops, keep the land clean, and hand-pick the bugs from the plants, especially while the latter are young.

A lucerne pest

IV. Animals injurious to Lucerne

The Berseem Worm

Caradrina exigua, Hubner

Several outbreaks of this pest occurred during 1906.

In Egypt it has been observed to feed on cotton, bamia, berseem, lucerne (*berseem hegazi*), maize (*dura shami*), sugar-cane and other plants,[1] but in this country was only noticed attacking lucerne.

Egg.—In colour the egg varies from yellowish to pale green and is marked with radiating vertical ribs and smaller concentric ridges.

Larva.—In general appearance the caterpillar is green with a broad darker stripe on either side of the sub-dorsal lines. The colours are subject to great variations.

Length, about 26 mm.

Pupa.—The pupa is yellowish brown in colour, with reddish-brown rings at the bases of the fourth to the seventh abdominal segments.

Length, 10–11 mm.

Adult.—A greyish-brown moth 9–11 mm. in length and with a wing expanse of 22–27 mm. Thorax and abdomen greyish-brown. Fore-wing greyish-brown with a yellowish kidney-shaped mark on the median area. Hind-wing opalescent white with veins, margin and apex, fuscous.

Life-history and habits.—The female deposits her eggs in masses, usually on the undersides of the leaves, and covers them with greyish down. In about four days the larvæ appear and commence feeding on the lower epidermis. When about half grown they devour the whole substance of the leaf with the exception of the larger veins, and at the same time acquire the habit of feeding only by night and spending the day hidden in the soil.

When full-fed they pupate in earthen cells, immediately below the surface of the ground.

The life-cycle occupies usually about twenty-eight days.

Owing to the young larvæ eating only the under-surface of the leaves and leaving the upper epidermis intact, infested fields of lucerne have the appearance of being scorched.

Preventions and remedies.—The usual remedies employed in Egypt are hand-picking and flooding. In America, spraying the infested plants with arsenical sprays or with kerosene emulsion spray has been found successful.

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[1] Willcocks, *Year-book of Khedival Agricultural Society*, 1905, p. 107.

Where the caterpillars are attacking lucerne, closely feeding it off with sheep would probably prove effective. Large numbers of the larvæ would be either eaten or trampled upon, while at the same time the ley would benefit from the droppings of the animals.

A disease that appeared to be of a bacterial nature cleared off swarms of the caterpillars that were feeding on lucerne at the Government Experimental Farm at Halfaya in 1906.

V. Animals injurious to Jute (*Molokhia*)

Jute pests

The Green Molokhia Worm

Gonitis involuta, Walk.

Plate XXVII., fig. 2

The larva of this moth was frequently noticed during 1906 feeding on jute, which is grown by the natives as a potherb, and known to them as *molokhia*.

Larva.—A bright green caterpillar about 30 mm. in length.

Head, green with a faint brown median stripe. First segment, dark green with two white dorso-lateral spots. A yellow transverse dorsal bar on the eleventh segment. Two pale longitudinal lines originate in the white spots on the first segment and extend the length of the body. A similar line on either side below the spiracles. Small black dots ringed with white and in some cases bearing a hair scattered over the body.

Adult (fig. 2).—A dark brown moth, 12–14 mm. in length and with a wing expanse of 28–35 mm. Fore-wing brown with a wavy transverse line. Margin scolloped. Fringe brown with black spots.

Hind-wings, uniform dusky brown with a pale fringe.

In some specimens there are two black spots on the fore-wing.

Remedial treatment.—Where the caterpillars are very numerous, hand-picking should be resorted to.

The Red Molokhia Worm

Tarache tropica

Plate XXVII., fig. 8

This caterpillar was found attacking molokhia in company with *Gonitis involuta.*

Larva.—A reddish-green caterpillar 20–25 mm. in length.

Head, chestnut-brown. Legs, black. Body, greenish. Fifth to eighth segments tinged with red, remaining segments tinged with yellow. Darker median dorsal line edged with black. White longitudinal lateral lines level with the spiracles. Many white and yellowish spots and black tubercles, some of which terminate in a hair.

Adult (fig. 8).—A green-and-white moth 7–8 mm. in length and with a wing expanse of 15–20 mm.

Female.—Thorax, olive green edged with white laterally and anteriorly. Fore-wing, olive green with white patches, mostly anteriorly placed. In the white patches are small dark rings. Fringe, green with two white patches. Hind-wings, smoky grey.

Male.—Resembles the female in general markings but white largely predominates. Hind-wings, silvery white.

Remedial treatment.—Hand-pick the caterpillars.

Locusts

VI. Locusts

Schistocerca peregrina and *Acridium ægyptium*

Undoubtedly the most important of all the insect pests from which agriculturists in the Sudan suffer are migratory locusts. The two species that occur regularly are the yellow locust—*Schistocerca peregrina*—and the reddish-brown locust—*Acridium ægyptium.*

Almost every year, after the rains have commenced, swarms of young locusts emerge from the soil, where the eggs which gave rise to them have been hidden, and proceed to devastate the country. Where the eggs have been laid among the cultivations the "hoppers," as the immature locusts are called, are at once seen, and frequently large numbers are destroyed, but where the swarms occur in the desert they are often not noticed until, having attained maturity, they take wing and appear in countless myriads on cultivations situated possibly many miles from where they passed the first days of their existence.

The occurrence of locust swarms, however, is not limited to the rainy season, as instanced last year in Dongola Province. Vast swarms appeared in the Debba, Korti and Merowe mamurias on June 2nd, coming from the Bayuda desert, and remained until June 22nd, when they disappeared in the direction of Abu Hamed. During that time they completely devoured the summer crop of dura, which was then just appearing above the ground, and stripped the date palms of their leaves, and in some cases of their fruit as well.

It is not easy to estimate the value of the crops destroyed by locusts, consequently the following figures for the year 1907, which have been furnished by the Governors of the various provinces, must be looked upon as merely approximate.

Losses due to locusts

For the Blue Nile Province the loss to Government in taxes is estimated to have been £E 3,500 and to the country as a whole to have been £E 38,000. For the province of Sennar the figures given are respectively £E 3,695 and £E 36,950, and for the province of Kassala £E 1,200 and £E 7,000–8,000. Other provinces suffered to varying extents, but these figures will be sufficient to convey an idea of what the arrival of a swarm of locusts in a district means to the inhabitants.

In some provinces, notably in those of Berber and Khartoum, strenuous efforts have been made by those in authority to control the locusts, but owing to various reasons, such as (1) lack of funds, (2) scantiness of population, and (3) reluctance on the part of the natives to make any serious endeavour to collect locust eggs or to destroy hoppers, unless they are actually attacking their crops, these efforts have not met with unmitigated success.

The various methods that may be adopted in dealing with locust swarms were fully described in the Second Report of these Laboratories, so it is only necessary here to point out the advantages and disadvantages that attend them.

Destruction of eggs.—This is only practicable where the egg batches are deposited fairly closely together, and where there is sufficient labour available. From observations made last year on the yellow locust—*S. peregrina*—the swarms appear to spread themselves over large areas before commencing to lay their eggs.

Destruction of hoppers.—The nature of the country, and the conditions under which the locusts occur, render the various methods known as burning, crushing, trapping and catching of little real value, except under special circumstances. Sometimes it happens that the scrub can be burned—in Berber Province during 1907 large numbers were destroyed in the vicinity of the Atbara by driving them into the "Dom" scrub and firing it—but as a rule the desert scrub will not burn without the aid of some inflammable substance such as paraffin. Where the hoppers occur in open desert, they can be driven into trenches, but when among scrub, at the slightest alarm they take refuge in the bushes.

Attempts were made during 1906 to infect living locusts with a fungus that had been found growing on the bodies of dead locusts at Suakin in the previous year,[1] and which during the interval had been cultivated on agar slope. In every case these attempts were unsuccessful, and in view of this the following extracts and notes from an article on the South African Locust Fungus—*Empusa grylli*—by Mr. I. B. Pole Evans, published in the *Transvaal Agricultural Journal* of July, 1907, may be of interest. The locust fungus

"Diseased locusts were first noticed in Natal and the Transvaal in the year 1895. The Natal specimens were examined by Mr. Medley Wood and found to be infected with a fungus belonging to the *Entomophthoreæ*. Specimens were also sent to the British Museum and Mr. Medley Woods' determination confirmed. The following year, outbreaks of locust disease were again observed in Natal and several parts of Cape Colony. The accounts of the disease from both Colonies agree in the fact that the dying insects always betook themselves to the tops of the grasses and other herbage, where they remained clinging to their posts long after death.

"Attempts at the cultivation of this fungus were made by Doctors Edington and Black at the Grahamstown Bacteriological Institute. They succeeded in growing a fungus on a large scale, which was afterwards distributed among agriculturists in order that they might infect with disease the swarms of locusts whenever they occurred. This fungus, however, has proved to be a saprophyte (a *Mucor*), and not the parasite *Empusa grylli*, which is the main cause of the mortality that occurs from time to time amongst locusts in South Africa, when a fungus agent is at work.

"*Empusa grylli* is entirely dependent for its growth on the living tissues of its host and cannot be cultivated in artificial media. It is difficult to see, therefore, how it can be put to any economic use."

The employment of destructive agents is the method that will probably prove to be best suited to the Sudan, and is the method chiefly in vogue in Natal and the Transvaal. The destructive agent usually employed is arsenic in the form of arsenite of soda. A liquid containing this compound is sprayed over the herbage on which the locusts are feeding, with the result that the insects are poisoned.

Another method is to lay about poisoned baits, while a third is to spray the locusts themselves with what are known as "contact" sprays—non-poisonous liquids that kill by contact. A drawback to this is that a very much larger quantity of spray is required than is the case when a poisonous spray is employed.

The sum of £E 700 has been granted by the Government with which to make trials of these methods during the coming season. These trials will be restricted to one province—the Province of Berber—but should they prove successful, a larger sum will be applied for in order that a general effort may be made to control the locusts throughout the Sudan in the future. Grant for locust destruction

Natural enemies.—Locust swarms are invariably preyed upon by numbers of birds, animals and insects, which do a great deal towards lessening their numbers.

Among the insects, beneficial in this way, noticed during 1907, was the larva of one of the *Cantharididæ*, or blister beetles. At Kalakla, nearly 50 per cent. of the egg batches of the yellow locust contained these larvæ.

The larva of the blister beetle, *Epicauta vittata*, has been recorded by Riley[2] to feed on the eggs of North American locusts of the genus *Caloptenus* in a similar way.

[1] *Vide* Second Report, Wellcome Research Laboratories, 1906, p. 50.

[2] Report United States Entomology Commission, i. 1878, p. 297.

Pests of trees and shrubs

VII. Animals injurious to Trees and Shrubs

The Orange Tree Butterfly

Papilio demoleus

Plate XXXII

A pest of orange and lime trees

This is the only insect pest of any importance that has, up to the present time, been noticed attacking orange trees in this country. Specimens of the adults have been received from the Bahr-El-Ghazal and the larvæ have been recorded as defoliating orange and lime trees at the American Mission Station on the Sobat. It is moderately plentiful in Khartoum.

It is found throughout Africa and is said to be the cause of considerable damage to young citrus trees in the Transvaal.

In the Sudan the larvæ have only been seen on citrus trees, but if these are wanting they are able to feed on various other plants.

Egg (fig. 7).—In shape the egg is spherical with the surface attached to the leaf or twig slightly flattened. Colour, yellowish-brown. Diameter, 1·25 mm.

Previous to hatching, a dark spot appears near the top of the egg. After hatching, the empty egg shell, which usually remains attached to the leaf, resembles a small seed pearl.

Larva (fig. 2).—A stoutly built caterpillar, with the second, third and fourth segments much thickened, giving it a hunch-backed appearance.

The larva passes through two distinct stages before attaining maturity.

On first hatching it is very conspicuous in colour, but is protected by its close resemblance to the excreta of a small bird.

Head, dark brown. Body, brownish to bluey-black. First segment and sides of the second segment yellow to white. Sides of the fifth and sixth and dorsal surface of the seventh and eighth segments yellow to white, forming a broad irregular V-shaped mark. Sides of the tenth and eleventh segments yellow to white. Anal segment white. A pair of chestnut yellow forwardly-projecting tubercles or horns on the first segment. Two longitudinal rows of tubercles on the dorsum corresponding in colour to the segments on which they are situated. A transverse row of six tubercles on the third segment and a similar row of four on the fourth segment.

In the second stage (fig. 5) the larva is bright green in colour, sometimes with a yellowish tinge.

Head, dark brown. Junction of first and second segments, black. A transverse band varying in colour from brown to black and studded with small tubercles, anteriorly placed on the third segment, and a similar band, posteriorly placed on the fourth segment. These bands meet at the sides, enclosing a green area. Fifth segment, anteriorly edged with black. A brown to black patch begins on either side of the seventh, and extends upwards and backwards on the eighth and ninth, segments. Anal segment, brown to black. On the first segment is a pair of large tubercles, chestnut-brown in colour, and a similar pair is situated on the anal segment. Minute chestnut-brown tubercles on the eleventh and twelfth segments.

Jointed legs, chestnut-brown. Prolegs, white. Venter, greyish-white to grey.

In common with the other members of the family *Papilionidæ*, the larva possesses in both stages a retractile organ, situated on the first segment, known as the *osmeterium*.

A mature larva varies from 35 to 40 mm. in length.

Pupa (fig. 1).—In colour the pupa is usually ashy-grey. It is somewhat spindle-shaped and bears on the head two serrate horns and on the thorax a pronounced dorsal projection and two small lateral projections.

PLATE XXXII

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C. M. BEARD

THE ORANGE TREE BUTTERFLY, *Papilio demoleus*

1. Pupa *in natura*
2. Larva (first stage) on orange leaf
3. Adult
4. Orange leaf bearing an egg
5. Larva (second stage)
6. Larva (second stage) with osmeterium extruded
7. Egg

Illustrations are natural size unless otherwise indicated

Length, about 30 mm.

Adult (fig. 3).—A conspicuous greenish-black butterfly with yellow markings. *Length*, about 24 mm. Wing expanse, 85–105 mm.

Margin of wing scolloped, with centre of scollops yellow. An irregular row of yellow spots parallel to the margins on both fore- and hind-wings. A second row roughly parallel to the first—on the hind-wing these spots coalesce and form a yellow stripe. Three to five yellow spots near the costal border on the fore-wing.

An "eye," composed of brown encircled with blue, is situated near the costal border of the hind-wing and a more brilliant "eye" composed of brown, blue, black, red and yellow on the hind border of the hind-wing.

Two yellow stripes on the face extend over the head and thorax and expand into broad lateral stripes on the abdomen.

Life-history and habits.—The eggs are deposited singly, usually on the upper surface of a young leaf, though sometimes they may be found on the petiole or on the twig.

Difficulty of recognising the larva

The larva is sluggish in its habits and appears to be unable to cling to the leaf without the aid of a slight web of silk, which it spins over the surface of the leaf as it progresses. It spends the greater part of the day lying lengthwise over the midrib, in which position it so exactly resembles the excreta of some small bird that it is not readily recognisable as a caterpillar (fig. 2).

It feeds on the foliage, usually first attacking the young terminal leaves and eating its way steadily downwards. Sometimes it will even devour the soft growing extremity of the twig itself.

When it has attained a length of 20–25 mm. it passes into the second stage, in which it is not easily distinguishable from the foliage on which it is feeding.

If disturbed or alarmed the larva suddenly everts its osmeterium—a V-shaped orange-coloured process with red tips—and strikes backwards with it, at the same time emitting a peculiarly offensive smell from glands situated in the organ.

When full-fed it pupates, affixed to one of the stouter twigs or branches. The cremaster is attached to the support by a web of silk, while the pupa is maintained in a more or less upright position by a band of silk which passes round the thorax.

The adult emerges in from six to seven days.

Preventions and remedies.—On young trees the larvæ and even the eggs can be hand-picked. Where the caterpillars occur in numbers on older trees they can be destroyed by means of an arsenical spray.

Rose Chafers attacking Ornamental Trees

Pests of ornamental trees

Pachnoda savignyi, G. and P., and *Stalagnosoma cynanche*, G. and P.

Plate XXX., figs. 2, 3

These are the two more common of the cetonids that occur in the northern parts of the Sudan.

The larger of the two—*Pachnoda savignyi* (fig. 2)—is well known to gardeners in Khartoum. In colour it is chocolate brown, with the dorsum of the prothorax margined with yellow. Elytra laterally and apically margined with yellow and with a broad yellow transverse bar.

Length, about 20 mm.

Stalagnosoma cynanche (fig. 3) was noticed in large numbers at Shendi. It is dark brown in colour with gold markings. Dorsum of the prothorax with a broad lateral stripe beginning on the bases of the elytra and extending on to the head. Elytra each with three lateral patches and two median smaller marks. Pygidium with two gold-coloured areas.

Length, 9–12 mm.

Both species feed freely on the foliage of trees, and when present in any numbers are capable of doing a considerable amount of damage. A large green buprestid (fig. 7) sometimes attacks trees in a similar way.

Preventions and remedies.—The beetles can usually be jarred or shaken from the trees, collected and destroyed. A poisonous spray applied to the foliage of the trees on which they are feeding would also probably prove effective.

Pest of dates

The Date Scale

Parlatoria (Websteriella) blanchardi, Sarg. Tozz.

Plate XXVIII., figs. 1–3, 6

This coccid occurs on date palms throughout the northern parts of the Sudan, and is very common in Khartoum. Many of the dates exposed in the streets for sale from the 1906 crop were smothered with this insect.

It usually confines its attentions to the date palm, but recently it has been recorded by Draper[1] to attack yellow jasmine and periwinkle.

It is found throughout Northern Africa, and has also been recorded from Australia.

The male scale (fig. 2) is about 1 mm. in length and elongate in form. Colour, greyish-white; pellicle, yellowish-brown.

The female scale (fig. 3) is about 1·5 mm. in length and ovoid in form. It is almost entirely covered by the second pellicle, there being only a narrow, semi-transparent, greyish-white secretionary border. Second pellicle, yellowish-brown with a dark brown centre. First pellicle, yellow to dark brown.

Remedial treatment.—Spray the infested plants with kerosene emulsion.

Animals injurious to Stored Goods and Timber

Pests of stored goods

I. To Stored Goods

The Horn Beetle

Dermestes vulpinus

Plate XXVIII., figs. 4, 5

Trophies of the chase, such as heads and skins, are often seriously damaged by this pest.

The *adult* (fig. 4) is black in colour, with the head, front and sides of the pronotum and the venter clothed with ashy-grey pubescence; the mouth parts, occiput and scutellum, with golden pubescence. A few ashy-grey hairs are scattered over the elytra. Antennæ clubbed.

Length, 7–9 mm.

The *larva* (fig. 5) is clothed with long black backwardly-projecting hairs, and bears a tuft of similar hairs on the anal segment.

Length, 12 mm.

Preventions and remedies.—Paraffin will destroy this pest in all its stages.

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[1] Notes on Injurious Scale Insects and Mealy Bugs of Egypt.

The Clothes Beetle

Anthrenus vorax

Plate XXVIII., figs. 7, 8

This is the pest that is responsible for the holes that appear in clothes, blankets, etc., that have been stored for even only a short time.

The *adult* (fig. 7) is a deep chestnut-brown beetle, almost spherical in shape and densely clothed with golden, white and very dark brown scales.

Length, 2·75–4 mm.

The little hairy *larva* (fig. 8) is only too well known to residents in this country. The thoracic and the first four abdominal segments are dark brown and clothed with long black backwardly-projecting hairs. The fifth, sixth and seventh abdominal segments are yellow, more sparsely clothed with hairs, and bear lateral, backwardly-projecting tufts or brushes of black hairs. A caudal tuft of hairs is situated on the anal segment. A pale median line extends the length of the thoracic and the first four abdominal segments. Intersegmental spaces, pale.

A common pest of clothing

Length, 5 mm.

Preventions and remedies.—Clothes—with the exception of cotton goods, which this beetle will not eat—blankets and other articles liable to the attack of this pest should be stored in insect-proof cases—such as tin uniform cases. Before being put away the contents of the cases should be fumigated with carbon bisulphide.

The fumes of burning sulphur are also poisonous to the clothes beetle, but it must be remembered that they will also affect certain dyes, more especially those of vegetable origin.

Great care must be observed in using carbon bisulphide, as its fumes with air form a highly explosive mixture.

Camphor, naphthalene and like substances are useful in keeping beetles away from uninfested clothes, but have no effect on either eggs, larvæ or adults when once the clothes have become infested.

A Seed Beetle

Attogenus, sp.

Plate XXVIII., figs. 9, 10

Several other members of the family *Dermestidæ* occur, attacking seed, biscuits, museum specimens and other vegetable and animal products. Among these is a species (fig. 9) of *Attogenus*, which has several times been noticed causing considerable damage to seed.

Pests of seed, flour, grain tobacco and beans

The *larva* (fig. 10) is yellow in colour and clothed with yellow hairs. The sixth, seventh and eighth abdominal segments bear brushes of short reddish-brown hair; and the eighth segment bears, in addition, a caudal tuft of long yellow hairs.

The Confused Flour Beetle

Tribolium confusus, Dav.

This beetle occurs frequently in stored dura and other grains, and has also been noticed attacking museum specimens.

The *adult* is a flattened, reddish-brown beetle about 4·5 mm. in length.

It appears to be practically omnivorous and is recorded to feed on all sorts of grain and grain products, snuff, orris root, red pepper, etc.

There are upwards of four broods in the course of the year.

The Saw-toothed Grain Beetle

Silvanus surinamensis, Linn.

A box of dried figs, badly infested by this pest, was sent to the laboratories during 1906.

The *adult* is a slender flattened dark brown beetle, 2·25–3 mm. in length, and can easily be recognised by the presence of two shallow longitudinal grooves on the dorsum of the thorax, and six saw-like teeth on either side.

It is recorded to attack edibles of almost every description, including grain, flour, condiments and herbs.

There are upwards of four broods in the year.

The Cigarette Beetle

Lasioderma serricorne

Egyptian cigarettes containing this beetle were received during 1907 from El Kaim. Jackson Bey.

This pest attacks dried tobacco of all kinds and will also feed on cayenne pepper, ginger, rice, and many other substances.

The *adult* is a chestnut-brown, humpbacked beetle, about 3 mm. in length. Antennæ serrate.

The damage done to cigars and cigarettes is very noticeable, owing to the habit this pest has of eating holes in the wrapper.

There are upwards of six broods in the year.

A Bean Weevil

Bruchus, sp.

A sample of beans received from Shendi was infested by one of the pseudo weevils, or *Bruchi*. All the members of this genus are seed eaters, but are not true weevils, though popularly known as such.

Several species of *Bruchi* are known to attack beans and peas.

The life-histories of these bean weevils differ from those of many of the store pests in that the beans are first attacked in the field, the adult female laying her eggs in the young developing beans. The larvæ continue to feed within the beans until after the crop has been harvested, and in some cases the adults resulting from this brood will deposit their eggs on dried beans in the granary.

The species in question continued to breed in the beans, in which they had been received, for several months, until the seeds were absolutely riddled with holes.

The *adult* is about 4 mm. in length, and comes very near *Bruchus obtectus*, Say.

Its life-cycle can be completed in forty days, and possibly in less.

est of rice

The Rice Weevil

Calandra oryza, Linn.

Dura containing this beetle was sent to the Laboratories during 1906.

The *adult* is a dark brown, almost black weevil, with four dull reddish spots on the elytra.

Length, about 4 mm.

It attacks wheat, maize and other grains and grain products.

There are upwards of four broods in the year.

The Grain Weevil

Calandra granaria, Linn.

This was found attacking stored dura in company with the rice weevil.

The *adult* is chestnut-brown in colour and 4–5 mm. in length. Unlike the rice weevil, it has no powers of flight, the elytra being firmly cemented together.

There are upwards of four broods in the year.

Preventive and remedial measures against insect pests of grain and other stored goods

Care should first be taken that the rooms or cases in which goods, such as clothes, grain, tobacco, etc., liable to be attacked by the various pests, are to be stored, are free from these pests, and that the windows, doors or other openings are, as far as possible, insect proof. No goods should be placed in the store unless they are known to be free from store pests. If infested, before being placed in the store they should be fumigated with carbon bisulphide. Fumigation for store pests

Such fumigations should be carried out in the following way. The goods to be treated should be placed in an airtight bin, the cubic content of which is known. A measured quantity of carbon bisulphide should be poured into a shallow dish, placed on the top of the goods, the lid closed down, and the bin left for from twenty-four to thirty-six hours. At the end of this time the lid should be opened and the fumes of the carbon bisulphide allowed to escape.

Carbon bisulphide should be used at the rate of 1–1½ lb. for every 1000 cubic feet of air space.

It must not be forgotten that carbon bisulphide vapour, with air, forms a mixture that explodes at a comparatively low temperature (297·5° F.).[1] A bin used for fumigating purposes, therefore, is best kept in an isolated shed, and, when in use, precautions taken that no fire is brought near it.

II. To Timber

Sūs

Sinoxylon senegalense

Plate XXX., figs. 10, 11

Many wood-boring beetles occur in this country, perhaps the most common being one of the augur beetles, *Sinoxylon senegalense*, known to the natives as the "sūs."

The *adult* (fig. 10) is dark brown to black in colour and a typical bostrichid in appearance. Each of the elytra bears on its posterior portion a backwardly-projecting spine.

Length, about 7 mm.

Normally the sūs feeds in dead wood, tunnelling in all directions and producing what is sometimes known as "powder post injury" (fig. 11). It does not appear to attack healthy trees. An insect destroying wood

The method of tapping a hashab tree for gum is to remove a strip of bark: the gum then slowly exudes from the wound thus made.[2] When, as sometimes happens, a branch is seriously weakened by the removal of too large a strip of bark, it becomes liable to the attack of the sūs.

[1] *United States Department of Agriculture, Farmers' Bulletin*, No. 145.

[2] *Vide* Report of Chemical Section.

The work of this augur beetle is most noticeable in the wood used by the natives in the construction of their huts. Here, if unchecked, it soon reduces a comparatively stout rafter or post to a mere shell.

Preventions and remedies.—All dead wood refuse should be collected and burnt instead of being allowed to lie about and constitute nurseries for this pest.

If timber of value is attacked it can be saved by a liberal application of paraffin.

Possibly "Solignum," recommended as a preventive against the ravages of termites, might also be of value against the sūs.

White ants

WHITE ANTS

Termitidæ

It would be difficult to estimate the extent of the yearly losses that are suffered by residents in this country from the depredations of termites, popularly known as White Ants, or, to the natives, as *Arda*. Not only do these tiny insects destroy the timbers of houses, telegraph poles and wooden structures generally, but in some places they even attack growing crops and trees. Working as they do under cover of darkness—for very few termites can bear the light of day—the damage is frequently done before their presence is suspected. The alacrity with which they discover the whereabouts of anything that is to them edible is extraordinary. Stout leather camel bags—*khurg*—hung on the wall of a rest house, have been utterly ruined in a single night. Poles arising from iron bases are not safe, for the white ants construct mud tunnels over the metal until the wood is reached. It is needless to multiply instances of their voracity, for their habits in this direction are only too well known.

Uses of termites

It must not be thought, however, that white ants are an unmitigated curse. Some of the larger species have been eaten and are said to be very palatable. Where available in any numbers, they constitute an excellent food for fowls. The substance of which the nests or termitaria, which some species erect, are composed, can be used in making floors; when moistened, it can be spread out like mud, and in drying sets very hard. These nests can also be used as fertilisers; in South Africa they have been strongly recommended for this purpose.[1]

In Khartoum

The common species in Khartoum, and one that is responsible for much of the damage done, is *Calotermes flavicollis*, T. *Termes bellicosus*, Smeathman, occurs in Sennar and Kordofan, and *Termes destructor*, Smeathman, in Kordofan and the Upper White Nile. *Termes natalensis*, Hav., has also been recorded from the Sudan.

A small termite taken by Dr. Swale in Halfa Province, near the Om Nabadi mines, has been identified as *Psammotermes hybostoma*, Desn.

Several other species occur which have yet to be identified.

Value of Solignum

Preventions and remedies.—From a series of experiments carried out by Mr. Butler, Superintendent of Game Preservation, in 1905–6, it would appear that we have in the liquid known as Solignum a perfectly reliable preventive against the ravages of white ants. The following is an extract from his report.

"As a result of eleven months' trial, including a rainy season, *I have not found one single piece of wood work treated with Solignum so much as touched by white ants.*

"I have baited moist ground with pieces of undressed wood until it was teeming with white ants, and then placed Solignumed pegs in this ground, and Solignumed planks and

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[1] *Transvaal Agricultural Journal*, July, 1906, p. 843.

boxes on the surface, and done my best to get them eaten by white ants—but after periods of from seven to eleven months, all treated wood, in or on the ground, is *absolutely untouched*."

Solignum can now be obtained locally in Khartoum, or from the makers, Messrs. Major and Co., Ltd., Hull.

Green Willesden canvas is also proof against white ants.

The Shipworm

Teredo

The shipworm—*Teredo*—is responsible for a considerable amount of damage to submerged timber in the harbour at Port Sudan.

This bivalve is a well-known pest in many countries. In Vancouver, it is said to have reduced a wooden pile supporting a pier to a mere spongework of wood in the short space of eighteen months,[1] while in Holland its ravages have led to the expenditure of many millions sterling. A marine pest

It tunnels in the wood, lining its burrows with a shelly deposit.

Preventive measures.—As yet, no really satisfactory preventive has been discovered, though many have been tried.

Closely covering timber with sheet copper to well above high-water mark was found to be prohibitive on account of its cost.

Closely covering the surface of the timber with large headed iron nails—which have quickly rusted into a solid mass—has been extensively tried, but the crust so formed has sooner or later been broken and the shipworm gained entry.

Timber impregnated with creosote oil—Bethell's process—will resist the teredo for periods varying from fifteen to twenty-five years. The quantity of oil injected per cubic foot varies from 12 lb. to 20 lb. with the temperature of the water and the density of the wood.

Among the few timbers that are, to a certain extent, resistant to the attack of the shipworm are teak, greenheart—*Necandra rodiæi*—and North Borneo ironwood.

Fungoid Pests

Cotton Anthracnose

Fungoid pests

Colletotrichum gossypii, Southworth

This fungus is responsible for a certain number of the cotton bolls which die before attaining maturity.

I have only noticed anthracnose on the bolls, but it may also attack seedlings and the stems and leaves of mature plants. In the two latter situations, however, it does not do much harm and probably exists mainly as a saprophyte.

A boll attacked by this disease shows small wet-looking depressed areas, frequently with reddish margins. These areas increase in size, and at the same time the development of that part of the boll affected is arrested. If only one carpel shows signs of attack, the others will continue to grow and the boll becomes one-sided. Usually, the whole boll withers and dies unopened or only partially opened.

In the case of young seedlings, the fungus attacks either the stem or the cotyledons and the plant soon succumbs.

Anthracnose is generally distributed on seed, the spores being carried about entangled in the lint that adheres to the seed coat. Care should be taken, therefore, not to use for sowing-seed that which has been saved from an infected crop.

[1] Shipley, *Cambridge Natural History, Zoology*, pp. 220, 221.

Cotton Root Rot

A root fungus

A fungus attacking the roots of cotton plants has been noticed on farms in the vicinity of Khartoum. It appears to be identical with the cotton root rot fungus (provisionally identified by Pammel as *Ozonium auricomum*, Link) that occurs in the United States.

I have only seen this disease during the rainy season and on young growing cotton.

The first signs of an attack of root rot are usually noticeable on a sunny day following a downpour of rain. Sometimes isolated plants, at other times whole areas, will flag and wilt as though from want of water. Within three days these plants will probably be dead. On examination, the rootlets and the bark of the tap root will be found to be quite rotten, and frequently there is a depressed area on the root just below the surface of the soil.

A spell of dry weather usually stops the spread of this disease.

Preventions and remedies.—The fungus being in the soil, the only course open to the farmer is to starve it out by growing on the infected land only those crops which are not susceptible to its attack. Dura, dura shami, wheat, barley and other cereal crops are said to be immune.

If it is not possible to completely rid the soil of this fungus, cotton should be included in the rotation not oftener than once in three or four years.

Care should be taken to keep infected land free from weeds. All remains of a diseased crop should be burnt.

Dangail

A rust fungus

A considerable loss to the wheat crop is occasioned every year by one of the rust fungi, probably *Puccinia graminis*, Pers., the black or summer rust of wheat.

The native name for this pest is "Dangail."

Puccinia graminis is a well-known pest in Britain, North America, Australia and other wheat-growing countries.

The symptoms of an attack are as follow: The young growing crop, on becoming infected, loses its healthy green appearance and becomes yellowish. If the leaves and stems are examined, small elongated orange-coloured spots bearing a fine powder will be seen. Later on in the season, black lines appear, especially on the stems and leaf sheaths. The head of corn is small and the grain frequently so shrivelled as to be practically worthless.

Life-cycle of a rust fungus

The following is a brief outline of the life-cycle of *Puccinia graminis* as it occurs in England.

The winter is passed in the teleutospore stage, the teleutospores arising from the black longitudinal lines seen on infected straw. These teleutospores, in the spring, give rise to smaller spores, known as sporidia, which are blown about by the wind until eventually some alight on the wild barberry (*Berberis vulgaris*, L.). Here they germinate and give rise to yellow patches and, later, little flask-shaped depressions on the upper sides of the leaves. Within these depressions are produced conidia, whose functions are unknown. Yellow patches then appear on the under sides of the leaves, and these give rise to cups, bearing æcidiospores, which escape in July to attack the wheat. Infection takes place through the stomata only, and about eight days later orange-coloured uredospores are formed, which are borne by the wind from plant to plant, thus rapidly spreading the disease. This spread by uredospores continues until the host plant has reached maturity, when the thicker walled teleutospores are produced, as being better suited for hibernation.

It is probable that in this country, the intermediate host-plant is dispensed with, as it has been proved that the sporidia from teleutospores are capable of directly infecting wheat seedlings.

Preventions and remedies.—The only course that can be recommended is the cultivation of rust-resistant varieties of wheats. In other wheat-growing countries, it has been noticed that certain varieties of wheat are less susceptible to rust than others, and by selection and crossing varieties have been produced which are almost, if not quite, immune against the disease. This might be attempted in the Sudan in districts where rust is prevalent, while varieties of wheat, known to be rust resistant in other countries, might also be given a trial.

Smuts

Dura is attacked in this country by several species of smut fungi. Smuts

The smuts belong to the family *Ustilaginaceæ* and are all parasitic on the higher plants. They are especially injurious to cereal crops.

The following is a rough outline of the life-cycle of one of the cereal smuts.

The fungus passes the resting period in the form of chlamydospores. These are usually sown with the seed and both germinate at about the same time. The chlamydospores give rise to conidia, and these infect the young seedling plants, infection taking place in the soil. The mycelium of the fungus spreads throughout the tissues of its host-plant, but does not produce any malformation until the head begins to form. It then attacks the ovaries of the flowers, which become metamorphosed into sacs filled with chlamydospores. On the sac rupturing these chlamydospores are blown about by the wind and many adhere to healthy grains. If this grain is used for seed in the following season, the chlamydospores are enabled to produce conidia and infect the seedlings in the manner described above.

Attacking cereals

Life-cycle of a smut fungus

The life-cycles of the various cereal smuts differ in detail.

Preventions and remedies.—The best method of dealing with the smut fungi is to sterilise the seed before sowing, and thus destroy the chlamydospores before they have had a chance to infect the seedling.

This can be done by soaking the seed in a solution of copper sulphate (1 lb. copper sulphate in 20 gallons water) for a period of from twelve to sixteen hours, and then placing it in a solution of milk of lime (14 lb. quicklime in 20 gallons water) for five minutes. The grain should be spread out to dry before sowing.

This method has been found to be effective against the smuts of wheat, rye and oats, and should prove of value against the dura smuts.

Dura plants infested by a smut fungus are usually conspicuous by their relatively larger size when compared with the surrounding healthy plants. It should be practicable, therefore, to collect by hand and burn the diseased heads before the chlamydospores have become sufficiently developed to be carried about by the wind.

Miscellaneous

Aspidomorpha, spp.

Plate XXX., figs. 6, 8

The two beetles illustrated on Plate XXX, figs. 6 and 8, are members of the interesting group *Cassidides*, sub-family *Cryptostomes*, family *Chrysomelidæ*. *Aspidomorpha chlorotica*, Oliv., was sent from Uganda by Mr. Dawe; *A. mutabilis* occurs in the Sudd region.

Bed-bugs

Cimex lectularius, Linn., and *Cimex rotundatus*, Sig.

Owing to the part they play in the transmission of the disease known as kala-azar, bed-bugs have recently sprung into considerable prominence.

The only species that has been found in the Sudan up to the present is *C. lectularius* (Fig. 53), but for purposes of comparison the Indian bed-bug, *C. rotundatus* (Fig. 54), is also here illustrated.

Fig. 53.—*Cimex lectularius*

Fig. 54.—*Cimex rotundatus*

Bed-bugs spend most of their time hidden in cracks in bedsteads, crevices in the walls of huts, and similar places, where they wait until a suitable host presents itself. They will feed equally readily by night or by day, and are not particular as to their hosts, although probably man is preferred. The eggs—white, flask-shaped bodies—are deposited by the females in their hiding-places, and the tiny active larvæ are ready for their first meal of blood shortly after their escape from the egg.

The two species—*C. lectularius* and *C. rotundatus*—can be readily distinguished by the shape of the prothorax. In *C. rotundatus* the dorsal surface of this region is uniformly convex, while in *C. lectularius* the lateral edges are flat, or even, in some cases, slightly concave.

A paper, in which these two bed-bugs are described and illustrated, has recently been published by Capt. W. S. Patton, M.B., I.M.S., and I am indebted to him for the specimen from which the above figure of *C. rotundatus* was taken.

PLATE XXXIII

C. M. Beard

1. *Mucidus sudanensis*, n. sp. (♀)
2. *Tæniorhynchus violaceus*, n. sp. (♀)
3. *Mimeteculex kingii*, n. sp. (♀)

Small illustrations indicate natural sizes

New Mosquitoes from the Sudan

AND

List and Synoptic Table of all the known Sudanese Species

BY

Fred. V. Theobald, M.A.

Imperial Ottoman Order of the Osmanieh (4th class); Fellow and Member of Council of the Society of Tropical Medicine; Honorary Member of the Société de Pathologie Exotique of France; Honorary Member of the Scientific Committee of the Royal Horticultural Society; Honorary Member of the Association of Economic Entomologists of America; Member of the Permanent International Commission on Agricultural Education; Vice-President of the Association of Economic Biologists; Honorary Consulting Entomologist to the National Fruit Growers' Federation, etc.; and Vice-Principal and Zoologist to the S.E. Agricultural College, Wye.

Note

Amongst the mosquitoes taken by Mr. H. King are six new species and a variety which may possibly be a distinct form. Six new species

The new species include a handsome *Mucidus* which comes near both the *Mucidus mucidus*, Karsch, and the *Mucidus africanus*, Theobald, and a *Tæniorhynchus* which is quite distinct and which is evidently a very brilliant species when alive, with metallic-violet and purple body.

A new genus, *Mimeteculex*, has had to be formed for one species (*M. kingii*), as I could not satisfactorily place it in any described group; the male being very marked on account of the unequal hind ungues, a character not known in any other male in this family. The *Mimomyia (M. circumtestacea)* is quite distinct from the other two known Sudanese species; from the series of it collected by Mr. King, the male genitalia of this genus have been figured.

Two *Uranotænia* have been taken, but they are so closely related that I have placed one only as a sub-species of the other, the difference mainly being one of colour; the type has a pale-scaled head, the sub-species a blue head, like *U. cæruleocephala*.

A salt-water culex is also new (*C. salus*) and *Stegomyia argenteopunctata*, Theobald, and *Scutomyia sugens*, Wiedemann, are recorded for the first time in this region. There are now forty-three species of *Culicidæ* known in the Sudan. A salt-water culex

List of Sudanese Culicidæ[1]

1. *Anopheles wellcomei*, Theobald, Rep. Gord. Coll., No. 1., p. 64 (1904), and No. 2, p. 67 (1906).
2. *Myzomyia funesta*, Giles, Rep. Gord. Coll., No. 1, p. 68 (1904), and No. 2, p. 69 (1906).
3. *Myzomyia nili*, Theobald, Rep. Gord. Coll., No. 1, p. 66 (1904), and No. 2, p. 68 (1906).
4. *Pyretophorus costalis*, Loew, Rep. Gord. Coll., No. 1, p. 70 (1904).
5. *Myzorhynchus paludis*, Theobald, Rep. Gord. Coll., No. 1, p. 70 (1904), and No. 2, p. 69 (1906).
6. *Cellia pharœnsis*, Theobald, Rep. Gord. Coll., No. 1, p. 70 (1904).
7. *Cellia squamosa*, Theobald, Rep. Gord. Coll., No. 2, p. 69 (1906).
8. *Mucidus africanus*, Theobald, Rep. Gord. Coll., No. 1, p. 71 (1904).
9. *Mucidus sudanensis*, n. sp., Rep. Gord. Coll., No. 3.
10. *Stegomyia fasciata*, Fabricius, Rep. Gord. Coll., No. 1, p. 71 (1904).

[1] The references given here are only in connection with the Gordon College Reports.

11. *Stegomyia argenteopunctata*, Theobald, Rep. Gord. Coll., No. 3.
12. *Scutomyia sugens*, Wiedemann, Rep. Gord. Coll., No. 3.
13. *Quasistegomyia unilineata*, Theobald, Rep. Gord. Coll., No. 2, p. 70 (1906).
14. *Etorleptiomyia mediolineata*, Theobald, Rep. Gord. Coll., No. 1, p. 71 (1904).
15. *Theobaldia spathipalpis*, Rondani, Rep. Gord. Coll., No. 1, p. 73 (1904); No. 2 p. 71 (1906); and No. 3, p. 255 (1908).
16. *Culex hirsutipalpis*, Theobald, Rep. Gord. Coll., No. 2, p. 72 (1906).
17. *Culex cumminsii*, Theobald, Rep. Gord. Coll., No. 1, p. 75 (1904).
18. *Culex pallidocephala*, Theobald, Rep. Gord. Coll., No. 1, p. 73 (1904), and Rep. No. 2, p. 79 (1906).
19. *Culex (viridis) guiarti*, Blanchard, Rep. Gord. Coll., No. 1, p. 73 (1904), and No. 2, p. 79 (1906).
20. *Culex neavei*, Theobald, Rep. Gord. Coll., No. 2, p. 76 (1906).
21. *Culex rubinotus*, Theobald, Rep. Gord. Coll., No. 2, p. 78 (1906).
22. *Culex dentatus*, Theobald, Rep. Gord. Coll., No. 1, p. 75 (1904).
23. *Culex fatigans*, Wiedemann, Rep. Gord. Coll., No. 1, p. 76 (1904).
24. *Culex salus*, n. sp., Rep. Gord. Coll., No. 3, p. 256 (1908).
25. *Banksiella luteolateralis*, Theobald, Rep. Gord. Coll., No. 2, p. 74 (1906).
26. *Mimeteculex kingii*, n. sp., Rep. Gord. Coll., No. 3, p. 258 (1908).
27. *Mansonia uniformis*, Theobald, Rep. Gord. Coll., No. 1, p. 76 (1904).
28. *Mansonia major*, Theobald, Rep. Gord. Coll., No. 1, p. 77 (1904).
29. *Mansonia nigra*, Theobald, Rep. Gord. Coll., No. 2, p. 80 (1906).
30. *Tæniorhynchus tenax*, Theobald, Rep. Gord. Coll., No. 1, p. 78 (1904).
31. *Tæniorhynchus tenax* var. *maculipes*, Theobald, Rep. Gord. Coll., No. 1, p. 99 (1904).
32. *Tæniorhynchus violaceus*, n. sp., Rep. Gord. Coll., No. 3, p. 262 (1908).
33. *Chrysoconops (Tæniorhynchus) aurites*, Theobald, Rep. Gord. Coll., No. 1, p. 77 (1904).
34. *Chrysoconops (Tæniorhynchus) annettii*, Theobald, Rep. Gord. Coll., No. 1, p. 77 (1904).
35. *Chrysoconops (Tæniorhynchus) cristatus*, Theobald, Rep. Gord. Coll., No. 1, p. 78 (1904).
36. *Ædeomyia squammipenna*, Arribalzaga, Rep. Gord. Coll., No. 2, p. 82 (1906).
37. *Mimomyia uniformis*, Theobald, Rep. Gord. Coll., No. 1, p. 80 (1904).
38. *Mimomyia circumtestacea*, n. sp., Rep. Gord. Coll., No. 3, p. 262 (1908).
39. *Mimomyia splendens*, Theobald, Rep. Gord. Coll., No. 1, p. 81 (1904).
40. *Uranotænia balfouri*, Theobald, Rep. Gord. Coll., No. 1, p. 82 (1904), and No. 2, p. 82 (1906).
41. *Uranotænia cæruleocephala*, Theobald, Rep. Gord. Coll., No. 1, p. 83 (1904).
42. *Uranotænia pallidocephala*, n. sp., Rep. Gord. Coll., No. 3, p. 266 (1908).
43. *Uranotænia pallidocephala* var. *cæruleus*, n. v., Rep. Gord. Coll., No. 3, p. 266 (1908).
44. Genus and species query. Rep. Gord. Coll., No. 1, p. 83 (1904).

Synopsis of Sudanese Culicidæ

A. Palpi Long in ♂ and ♀ (*Anophelinæ*)

α LEGS UNBANDED

Three pale costal spots; palpi black except at apex; fringe dark except at lower branch of veins 4 and 5 ... ... *Myzomyia nili*, Theob.

αα LEGS BANDED

β LEGS WITH NARROW APICAL BANDS

Costa with three large and two small pale spots, palpi with three pale bands *Myzomyia funesta*, Giles

Costa black, two yellow spots ... ... *Anopheles wellcomei*, Theob.

ββ LEGS BANDED AND SPOTTED

Abdomen with lateral scale-tufts and densely scaly

Black and silvery-white ... ... *Cellia squamosa*, Theob.

Brown and yellowish ... ... *Cellia pharœnsis*, Theob.

Abdomen no lateral tufts, abdomen not densely scaly ... *Pyretophorus costalis*, Loew

βββ LEGS WITH LAST THREE HIND TARSI WHITE ... *Myzorhynchus paludis*, Theob.

B. PALPI LONG IN ♂, SHORT IN ♀ (*Culicinæ*)

γ DENSELY SCALY, RAGGED SPECIES

Wing-fringe with five pale spots ... ... *Mucidus africanus*, Theob.
Wing-fringe with eight pale spots ... ... *Mucidus sudanensis*, Theob.

γγ NOT DENSELY SCALY

δ *Wing scales normal*
ε Wings spotted
Thorax with white lines ... . *Theobaldia spathipalpis*, Rond.
εε Wings not spotted
ξ Proboscis banded
Legs apically and basally banded
Abdomen with small basal semi-circular patches and basal lateral spots *Culex hirsutipalpis*, Theob.
Abdomen with broad basal white bands ... ... *Culex salus*, Theob.
ξξ Proboscis unbanded
α Legs basally banded
Thorax with six silvery spots ... ... *Scutomyia sugens*, Wied.
Thorax with two median yellow and silvery curved lateral lines *Stegomyia fasciata*, Fab.
Thorax with narrow median white line and white spots *Quasistegomyia unilineata*, Theob.

αα LEGS UNBANDED

β THORAX ADORNED

Black, six white thoracic spots ... ... *Stegomyia argenteopunctata*, Theob.
Thorax golden-yellow-scaled at the sides ... *Banksiella luteolateralis*, Theob.
Thorax rich reddish-brown with five dull yellowish lines ... *Mimeteculex kingii*, Theob.

ββ THORAX UNADORNED

ξ Wing scales linear

γ LARGE SPECIES

Abdomen unbanded, with large basal lateral pale spots... *Culex cumminsii*, Theob.

γγ SMALL SPECIES

δ ABDOMEN UNBANDED

Thorax brown
Pleuræ greenish ... ... *Culex guiarti*, Bl. (= *viridis*, Theob).
Pleuræ grey ... ... *Culex neavei*, Theob.
Thorax reddish-brown; abdomen with apical lateral pale spots *Culex rubinotus*, Theob.

δδ ABDOMEN BANDED

ε UNGUES OF ♀ SIMPLE

Head scales pale; traces of linear thoracic ornamentation and two dark ocellate areas *Culex pallidocephala*, Theob.
Head scales darker; no ocellate patches ... ... *Culex fatigans*, Wied.

εε UNGUES OF ♀ UNISERRATE ... ... *Culex dentatus*, Theob.

ξξ *Wing scales rather broad and long*

θ Golden yellow and purple species

Thorax brown, with brown and creamy scales; abdomen with apical dark bands, legs yellow, apices of joints dark ... ... *Chrysoconops annettii*, Theob.
Thorax yellow; abdomen yellow, last three tarsals black...*Chrysoconops aurites*, Theob.
Thorax black, with golden scales, legs black and orange with dark scale tufts *Chrysoconops cristatus*, Theob.

θθ DARK SPECIES

Abdomen metallic-violet ... ... *Tæniorhynchus violaceus*, Theob.
Abdomen brown, with scattered yellowish scales, last two segments with broad posterior bands of orange-yellow; thorax half pale scaled ... *Tæniorhynchus tenax*, Theob.
As above, but legs spotted ... ... var. *maculipes*, Theob.

ξξξ *Wing scales large and heart-shaped* ... ... *Etorleptiomyia mediolineata*, Theob.

ξξξξ *Wing scales broad and asymmetrical*

Thorax brown, with chestnut-brown and golden scales in centre, pale at sides; legs spotted and banded. *Length*, 4·5–5 mm. ... *Mansonia uniformis*, Theob.

Thorax with golden-brown scales and a pale silvery area before scutellum; first fork-cell long. *Length*, 6·5 mm. ... ... *Mansonia major*, Theob.

Blackish, with dark brown and golden scales forming ornamentation. Wings deep brown and white scales, some few heart-shaped ... *Mansonia nigra*, Theob.

C. PALPI SHORT IN ♂ AND ♀ (*Ædinæ*)

α WING SCALES BROAD AND ASYMMETRICAL

Wings ornamented, legs with scale tufts ... ... *Ædeomyia squammipenna*, Arri.

αα WING SCALES NARROWER

β Fork-cells long. ♂ proboscis much swollen

Thorax uniform, shiny-brown with small scattered black scales *Mimomyia uniformis*, Theob.

Thorax dark in middle, pale testaceous around ... *Mimomyia circumtestacea*, Theob.

Thorax apple-green scaled ... ... *Mimomyia splendens*, Theob.

ββ Fork-cells small. ♂ proboscis swollen only at tip

γ Thorax with a white-scaled line behind

Head pale ... ... *Uranotænia pallidocephala*, Theob.

Head blue and creamy ... ... *Uranotænia pallidocephala* var. *cæruleus*, Theob.

γγ Thorax without white line

Head blue ... ... *Uranotænia cæruleocephala*, Theob.

Head blue, dark in middle ... ... *Uranotænia balfouri*, Theob.

Genus, *Mucidus*, Theobald

"Mono. Culicid.," I., p. 268, 1901

Mucidus sudanensis, n. sp.

Plates XXXIII., fig. 1, XXXIV., fig. 1, XXXVII., fig. 6, and XXXIX., fig. 1

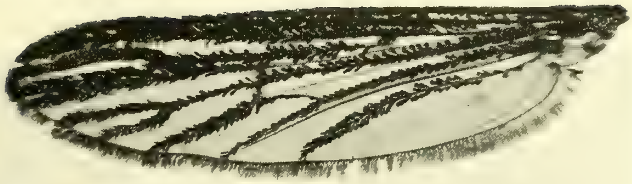
Mucidus sudanensis

Thorax yellowish-brown, with patches of shaggy grey scales. Abdomen bright ochreous with basal median and lateral white shaggy patches; the median patches being large on the last three segments. Legs pale ochreous with bands of dark-tipped and white outstanding scales; the femora with a white band towards the apex and one at the tip; tibiæ with white basal, median and apical bands; metatarsi with white basal and median bands; tarsi with white basal bands. Ungues equal, thick and serrated. Wings with eight pale areas to the fringe.

♀—*Head:* brown, with scattered loose white scales and a median broad line of twisted white scales; bright ochreous thin upright forked scales and golden hairs, a prominent border of narrow-curved creamy scales around the eyes. Antennæ bright ochreous, the basal segment with small white scales, the nodes dusky and also the verticillate hairs; frons and clypeus bright ochreous; palpi ochreous with large scattered loose white and dusky-tipped scales, apices entirely white scaled; eyes dark and metallic-brassy; proboscis ochreous with loose dusky-tipped scales, except at the apex, where they are snow-white.

Thorax: brownish, with very fine narrow-curved white scales in front, becoming dull yellowish behind; a small median patch of white twisted scales near the head and a patch on each side just behind it, two other pairs of patches further back almost continuous, and a dense tuft of long white thin-stalked scales projecting outwards in front of the wings, a few forming a median white line, more in number where it reaches the space before the scutellum,

PLATE XXXIV



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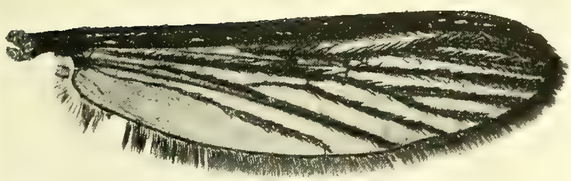

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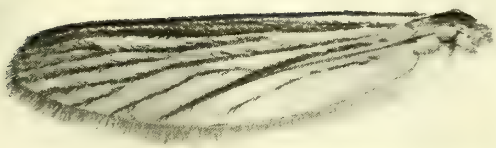

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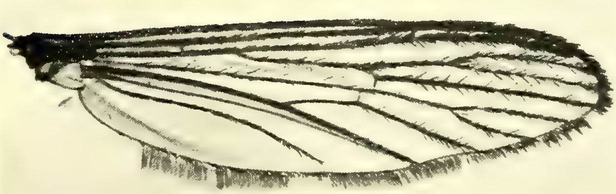


4

WINGS OF NEW CULICIDÆ

1. Wing of *Mucidus sudanensis*, n. sp. (♀)
2. Wing of *Culex salus*, n. sp. (♀)
3. Wing of *Culex salus*, n. sp. (♂)
4. Wing of *Mimeteculex kingii*, n. sp. (♀)

which has white scales on each side of it; some very small white scales forming a line on each side behind the wings; chætæ golden-brown, paler at the tips; scutellum with a tangled mass of long twisted white scales and long, thin, dense, golden-brown border-bristles; metanotum pale brown; pleuræ dark brown with patches of pale scales.

Abdomen: brownish, covered with flat, loose, bright ochreous scales, each segment with a basal white median patch of larger scales, somewhat triangular in form, and an outstanding basal patch of long white scales on each side, broadly spatulate at their apex with very thin stems; on the fifth and sixth segments the white scales are more abundant, the apical segment mostly ochreous but with some median white scales; there are also some flat dusky scales on each side of the median white ones, and some dusky-tipped rather outstanding ones behind, especially on the apex of the fourth.

Legs: ochreous covered with dusky-tipped and white scales, the former being ochreous at their base; fore femora with white scales at the apex and a narrow ring of white near it, tibiæ with basal, median, and apical white bands; metatarsi and tarsi ochreous; mid legs with femora the same and the tibiæ with broader white bands and more outstanding dusky-tipped scales; metatarsi white at the base and in the middle, first tarsal with a basal white band, rest unbanded; hind legs with the white bands still more pronounced and all the tarsi with basal white bands and the outstanding dusky-tipped scales more numerous than on the mid legs; ungues all equal, dark, thick and uniserrated.

Wings: clothed with ochreous, dusky-white and parti-coloured scales, the last two mainly towards the base of the wings; the first submarginal cell very much longer, but scarcely narrower than the second posterior cell, its base almost level with that of the latter, its stem about two-thirds the length of the cell, stem of the second posterior longer than the cell; posterior cross-vein longer than the mid and slightly in front of it; the third vein close to the second and continued to the base of the wing as a pseudo-vein; a distinct pseudo-vein continued from the upper branch of the fifth to the base of the wing, and a distinct pseudo-vein between the fifth and sixth ending at the tip of the fifth. The costal and first long vein mostly ochreous scaled, the latter with some dark scales towards the tip and some white and parti-coloured ones at the base; the upper branch of the second ochreous and its apical half, the rest with some scattered dark scales, the third and fourth the same, the latter with white and parti-coloured scales at the base; the upper branch of the fifth densely scaled from the cross-vein with dark scales, from the cross-vein to the junction with the lower branch and with it yellow scaled, apical half of stem yellow scaled, rest with dark parti-coloured and white scales; sixth with large, dense, mostly dark scales on the apical half; fringe with eight pale spots separated by seven dark spots placed at the tips of the fourth, fifth, and sixth veins and two further back; fringe at the apex yellowish, a dusky patch on the costa near the tip of the wing.

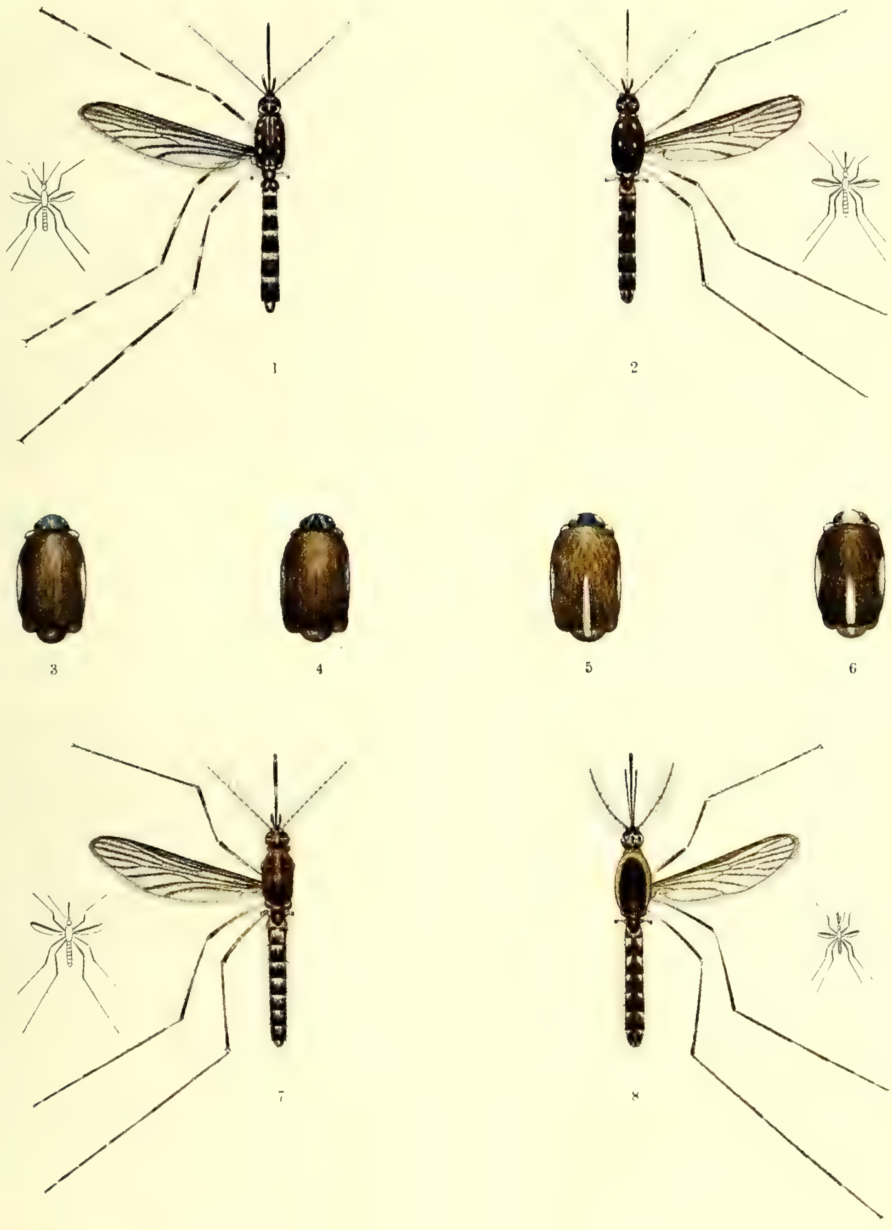
Length: 7 mm.

Habitat: Upper White Nile. Mr. King also found it breeding at Sangikia and took one at Kodok and one in Khartoum, which had probably been brought down in a boat.

Observations: Described from three females taken by Mr. King, who pointed out their difference from *M. africanus*, Theob. The species comes near it, however, and also *M. mucidus*, Karsch. From the former it may be told by the eight pale fringe spots and by different tibial banding, which is black on the basal half, white on the apical in *africanus*, whereas this species has three white bands; the second posterior cell also differs in having a longer stem.

From *M. mucidus* it differs in having less twisted scales on the thorax, eight instead of seven pale fringe spots, and by the presence of a mid-tibial band, and in the unbanded fore tarsi.

PLATE XXXV



C. M. Beard

1. *Scutomyia sugens*, Wied. (♀)
2. *Stegomyia argenteopunctata*, Theob. (♀)
3. Head and thorax of *Uranotænia cæruleocephala*, Theob.
4. Head and thorax of *U. balfouri*, Theob.
5. Head and thorax of *U. pallidocephala*, n. sp.
6. Head and thorax of *U. pallidocephala*, v. *cæruleus*, n. v., n. sp. (♀)
7. *Culex salus*, n. sp. (♀)
8. *Mimomyia circumtestacea*, n. sp. (♀)

Small illustrations indicate natural sizes

Genus, *Stegomyia*, Theobald

"Mono. Culicid.," I., p. 283 (1901)

Stegomyia argenteopunctata, Theobald

"Mono. Culicid.," I., p. 316 (1901), Theobald

Plate XXXV., fig. 2

Stegomyia argenteo-punctata

A single female sent by Mr. King from the Sobat River at Nasser.

It can at once be told from the other black-and-white mosquito with spotted thorax by the unbanded legs.

The thorax has two pairs of brilliant silvery-white spots and another pair placed more laterally; the abdomen of the female unbanded, but with basal white lateral spots, which in the male meet to form almost complete basal bands.

The uniserrated fore and mid ungues have very small teeth.

This species has so far only been recorded from Mashonaland.

Genus, *Scutomyia*, Theobald

The Entomologist, p. 77 (1904); "Mono. Culicid.," IV., p. 196 (1907)

Scutomyia sugens, Wiedemann (Plate XXXV., fig. 1)

Stegomyia sugens, Wiedemann

Culex sugens, Wiedemann (1828)

Culex vittatus, Bigot (1861)

Scutomyia sugens

"Auss. Zweiflüg. Ins." I. 545, 4 (1828), Wiedemann; *Ann. Ent. Soc. de France*, s. 4, t. 1 (1861), Bigot; "Mono. Culicid.," I., p. 300 (1901), and IV., p. 199 (1907), Theobald.

A single large ♀ taken by Mr. King in February, 1908, on hills to the east of Erkowit.

It may be pointed out here that in quite fresh specimens there are six white thoracic spots, not four, as I mentioned in Vol. 1 of my Monograph. I have since re-examined Bigot's type and find that there are just a few scales remaining, showing the position of the third pair of spots so clearly seen in the Sudanese specimen and those recently sent me from the Transvaal.

The scutellum is clothed with only flat scales and they are mainly silvery-white, but some specimens may show a few dusky or ochreous scales in the middle of the mid lobe.

The ungues of the hind legs are uniserrate, like the fore and mid.

There is considerable variation in the abdomen; some specimens show very marked lateral white spots as well as the basal bands, others not at all. There may also be numerous white scales on the sides of the thorax and in front of the scutellum.

The *distribution* is so far known to be as follows: Transvaal, very common; Uganda; Gambia; Free Town; Sierra Leone; Mashonaland; Aden; Nubia; India; Corsica; as well as the Sudan.

Genus, *Theobaldia*, Neveu-Lemaire

Comp. Rend. d. Sc. d. l. Soc. Biol., 29 Nov. (1902), Neveu-Lemaire; "Mono. Culicid.," III., p. 148 (1903), Theobald; "Les Moustiques," p. 390 (1905), Blanchard.

Theobaldia spathipalpis, Rondani

Culex spathipalpis, Rondani (1886)

Theobaldinella spathipalpis, Rondani

Culex longeareolatus, Macquart (1838)

Theobaldia spathipalpis

"Dipt. Ital. Prodo." I. (1886); "Mono. Culicid.," I., p. 339 (1901); III., p. 154 (1903); IV., p. 275 (1907); First Report, Gord. Coll. Wellcome Laboratories, p. 73 (1904); Second Report, p. 71 (1906); "Dipt. Exot.," I. 34 (1838), Macquart.

This large mosquito has been sent by Mr. King from Erkowit, where any number of them were seen in February.

It is probably widely distributed over Africa as well as Southern Europe and various Oceanic Islands, as Madeira, Teneriffe, Santa Cruz, St. Michael's, Azores, and the Mediterranean Islands. In Africa it has now been recorded from Egypt, the Sudan, the Transvaal, the Cape, and Algeria.

It has also been recorded from Naini Tal, India.

I feel almost certain that Macquart's *Culex longeareolatus*, from Madeira, is the same species; if so, Rondani's name must sink as a synonym.

Genus, *Culex*, Linné

Linn. "Syst. Nat." (1735); "Mono. Culicid.," I., p. 326 (1901), Theobald

Culex salus, n. sp.

Culex salus

Plates XXXIV., figs. 2, 3, XXXV., fig. 7, XXXVII., fig. 3, XXXVIII., fig. 2, XXXIX., fig. 2, and XL., fig. 1

Thorax deep brown, clothed with rather scanty pale dull creamy scales, somewhat brighter in places; pleuræ clear white. Head with similar scales to the thorax; proboscis black with a prominent whitish median band. Abdomen deep blackish-brown with broad basal white bands with dark scales here and there, giving a mottled appearance. Legs with narrow apical and basal pale banding.

♀—*Head:* deep brown with narrow-curved pale creamy scales; flat creamy lateral ones and six short pale bristles projecting forward; antennæ black, basal lobes deep blackish-brown; clypeus black; proboscis black with a broad pale creamy-white to white median band; eyes silvery.

Thorax: deep brown with rather scanty pale dull creamy scales, somewhat darker in two patches in front, and paler in front of the roots of the wings; chætæ apparently scanty, deep brown; scutellum brown with narrow pale scales and six brown posterior border bristles to the mid lobe; metanotum brown with grey reflections; pleuræ pallid greyish-white, somewhat pellucid, with some pale creamy scales.

Abdomen: deep blackish-brown with broad basal white-scaled bands which just extend on to the apices of the preceding segments and which have a few dark scales scattered over them; the first segment pale brown with a few dark scales and fine silk-like pale hairs; posterior border-bristles pale; last segment mostly pale-scaled; venter with still broader pale basal bands and even white scales dotted over the narrow dark apices.

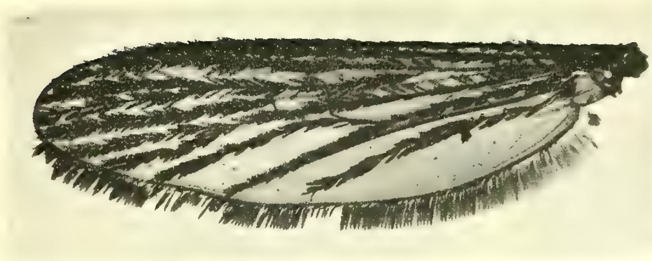
Legs: brown, pale at their base, coxæ almost silvery-white; a pale knee spot and a few paler scales on the femora; apex of tibiæ pale and base of metatarsi in the hind legs, a trace in the mid, none in the fore; narrow pale bands to some of the tarsal joints, involving both sides of the joints, most prominent on the hind legs; ungues equal and simple.

Wings: with dense scales on the branches of the second and fourth veins and third and apices of the other, rather broader than in *Culex* (sen. st.), fork-cells moderately long; the first sub-marginal longer and slightly narrower than the second posterior cell; its base very slightly nearer the base of the wing than that of the second posterior cell, its stem a little less than half the length of the cell; stem of the second posterior considerably less than half the length of the cell; posterior cross-vein more than three times its own length distant from the mid.

Length: 4·5–5 mm.

♂—*Palpi:* longer than the proboscis by nearly the whole of the apical segment; acuminate, last two segments of nearly equal length, the apical slightly the longer; hair-tufts scanty and short, dark; a basal pale band to both the last segments; the antepenultimate

PLATE XXXVI



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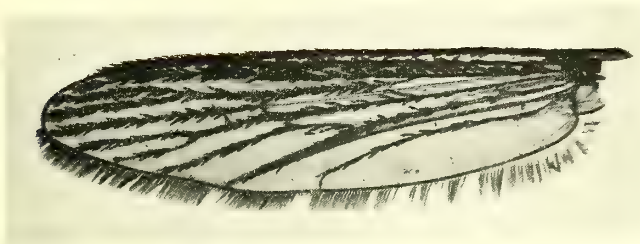

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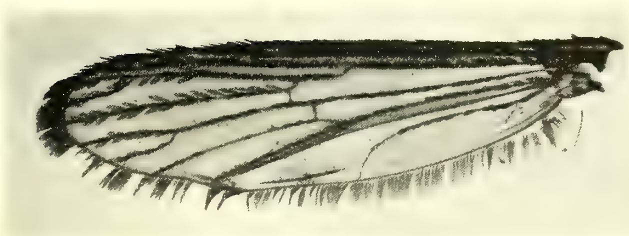

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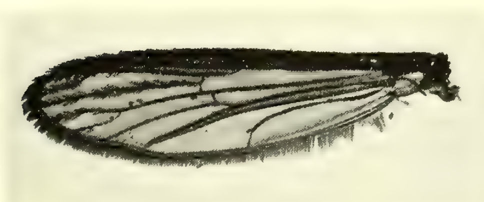


4

WINGS OF NEW CULICIDÆ

1. Wing of *Tæniorhynchus violaceus*, n. sp. (♀)
2. Wing of *Tæniorhynchus violaceus*, n. sp. (♂)
3. Wing of *Uranotænia pallidocephala*, n. sp. (♀)
4. Wing of *Uranotænia similis*, n. sp. (♀)

R

with two broad pale bands; proboscis broadly pale-banded, a group of long fine hairs below in the middle and another at the base. Wings with the fork-cells short, the first submarginal longer and much narrower than the second posterior, which is conically triangular in form; stem of the first fork-cell nearly two thirds the length of the cell; stem of the second fork-cell also nearly two thirds the length of the cell; posterior cross-vein more than twice its own length distant from the mid.

Genitalia, with the claspers, rather broad and sickle-shaped.

Length: 4·5 to 5 mm.

Habitat: Port Sudan (Dr. Crispin).

Observations: Described from two pinned females and micro-preparations of the male. It is a very distinct species coming in the *sitiens* group, easily told by the broad basal abdominal white bands with a few scattered black scales on them, the whitish pleuræ and banded proboscis and black antennæ.

The somewhat broad lateral vein scales of this and the allied species, such as *sitiens*, *vishnui*, *annulirostris*, *alis*, *etc.*, and their general uniform appearance and banded proboscis, make it probable that they should be placed in a genus to themselves. *Culex salus* has only been taken at Port Sudan in one place, namely, a tub sunk in a salt-water pool.

Genus, *Mimeteculex*, nov. gen.

Closely related to *Culex* and *Banksiella*, but differs from the former in the longer palpi of the female, and by having scales on the basal and second antennal segments, and from both in the male by having the palpi rather enlarged apically and with dense hair-tufts, and composed of three segments, there being only two in *Banksiella*, and also by the male hind ungues being unequal.

Head clothed with narrow-curved and upright forked scales and flat lateral ones, broader in ♂ than ♀; palpi moderately long in female, long in male, the two apical segments rather enlarged, tip blunt, hair-tufts moderate size; two basal segments of the antennæ with small scales. Thorax with very narrow-curved scales, prescutellar space scaly; scutellum with narrow-curved scales. Ungues of male *all* unequal.

A single species only so far known.

Mimeteculex kingii

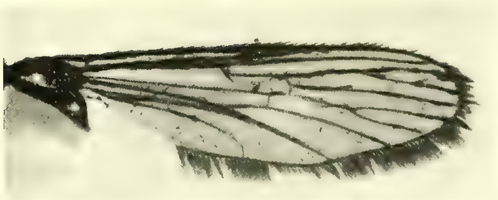
Mimeteculex kingii, n. sp.

Plates XXXIII., fig. 3, XXXIV., fig. 4, and XXXIX., fig. 4

Thorax rich reddish-brown with five dull yellowish lines, the outermost one shortest. Abdomen blackish-brown with basal creamy bands and an irregular creamy median line, widest on the posterior segments, giving the appearance of two quadrangular dark spots on each segment. Legs ochreous, darkened above and at the tips. Wings with a yellowish tinge and with yellow and dark scales on the costa and first long vein.

♀—*Head:* deep brown with narrow-curved creamy yellow scales, slightly smaller and narrower and brighter just in front, thin, black, upright forked scales behind, long dark chætæ projecting towards the middle line and some golden ones in front, placed on the median area. Eyes coppery. Antennæ with bright testaceous basal segment, also the next three, gradually becoming deep brown, small black scales on the basal and second segment; verticillate hairs rather long, dark; internodal hairs short, pale. Proboscis ochreous, dark scaled at the tip. Palpi ochreous, clothed with dark scales, through which the pale colour shows.

Thorax: deep-purplish brown, clothed with scanty, small, almost hair-like, curved yellow and rich brown scales, the former arranged in broad lines, one median, extending to the prescutellar space, which is scaly, then one on each side extending nearly back to the scutellum,



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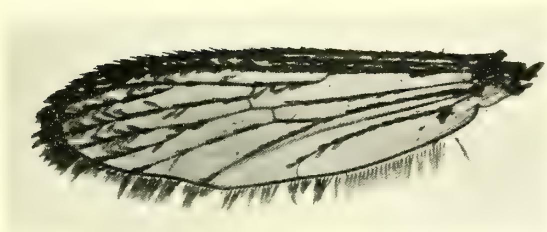

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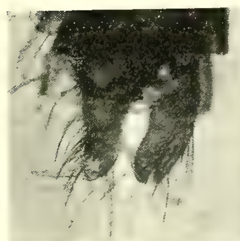

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New Culicidæ

1. Wing of *Mimomyia circumtestacea*, n. sp. (♂)
2. Wing of *Mimomyia circumtestacea*, n. sp. (♀)
3. Male genitalia of *Culex salus*, n. sp.
4. Male genitalia of *Mimomyia circumtestacea*, n. sp.
5. Male genitalia of *Tæniorhynchus violaceus*, n. sp.
6. Fore foot of *Mucidus sudanensis*, n. sp. (♀)

and another below running from the base of the wings forward for a short distance, looking somewhat paler than the others in certain lights; the median and lateral lines of chætæ dark in front, becoming golden, longer and denser behind, the median row ceasing before the scutellum; scutellum paler than the mesothorax, with narrow-curved pale scales and border-bristles either dark or golden according to the light; metanotum brown, with grey reflections at the sides and apex. Pleuræ dark, with one longish area of broadish pale scales passing down to the base of the first pair of legs, a smaller pale-scaled area behind.

Abdomen: with the basal segment, pale ochreous, with very pale scales and one or two scattered dark ones; the second, third, fourth and fifth segments with broad basal pale-scaled areas and a broad median area of pale scales, separating the dark-scaled lateral areas, the sixth with still wider basal and median pale areas, and the seventh with a broad median pale area and a narrow black line on each side; posterior border-bristles thin and pale, and there are also thin lateral bristles; a paler-scaled lateral line runs the whole length of the body with traces of darker scaled patches below; venter pale.

Legs: with ochreous scales and a few scattered dark ones, tarsi mostly dark-scaled; all the parts paler below, traces of pale knee spots; femora, tibiæ and metatarsi with short bristles, pale in some lights, dark in others; hind tibiæ longer than the hind metatarsi; ungues all equal and uniserrate.

Wings: with faint yellowish tinge; the costa with yellow scales and the base of the first long vein with some yellow scales, rest mostly dark, in certain lights the lateral scales of the second and fourth veins are pale; fork-cells of moderate length, the first sub-marginal longer and narrower than the second posterior, its base very slightly nearer the base of the wing than that of the second posterior, its stem a little more than half the length of the cell; stem of the second posterior about as long as the cell; posterior cross-vein about its own length distant from the mid, which is the same size.

Length: 5 mm.

♂—*Thorax:* as in the ♀, but the median pale line has a fine dark central line.

Head: with rather larger grey scales showing ochreous colours in some lights, and a median bare line; upright fork-scales dark at the back, brown in front; some long, straight, dark chætæ, paler in median region. Antennæ with flaxen plume-hairs, apical segments long, dark, not plumose; palpi long, the two apical segments of about equal length, thick; the apical one rather narrow towards the tip, which is blunt, ochreous basally, dusky towards the tips, hair-tufts flaxen and brown, of moderate size, apex of the antepenultimate segment dark-scaled, the penultimate with creamy scales on one portion.

Abdomen: much as in the ♀ but with more scattered pale scales, hairs brownish. Legs darker than in the ♀, the femora show a more distinct pale line; fore ungues unequal, both uniserrate; mid unequal, both uniserrate; hind unequal, but simple. Wings with the first, third and fourth long veins dark-scaled, the costa with many yellowish scales; fork-cells short; first sub-marginal longer and narrower than the second posterior, their bases nearly level, stem of the former, not quite as long as the cell of the latter, longer; posterior cross-vein longer than the mid and more than its own length distant from it.

Length: 5 mm.

Habitat: Upper White Nile, taken and found breeding at Taufikia. (H. King.)

Observations: Described from a perfect female and two males. It is a very marked species, easily told by the thoracic adornment. It is very variable in colour according to the light, but has a general yellowish-brown hue. The male ungues are very marked; it is the only mosquito I have seen in which the hind pair are unequal, and this and the palpi and wing scale structure excludes it from any previously described genus.

PLATE XXXVIII

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HEADS OF NEW CULICIDÆ

1. Head and mouth parts of *Tæniorhynchus violaceus*, n. sp. (♂)
2. Proboscis and palpi of *Culex salus*, n. sp. (♂)
3. Head of *Mimomyia circumtestacea*, n. sp. (♂)
4. Head of *Mimomyia circumtestacea*, n. sp. (♀)

Genus, *Tæniorhynchus*, Arribalzaga-Theobald

"Mono. Culicid.," II., p. 190, 1901

Tænio-rhynchus violaceus

Tæniorhynchus violaceus, n. sp.

Plates XXXIII., fig. 2, XXXVI., figs. 1, 2, XXXVII., fig. 5, XXXVIII., fig. 1, XXXIX., fig. 3, and XL., fig. 2

Thorax black with pale creamy scales in front, with faint greenish reflections. Abdomen metallic-violet, with small basal lateral creamy spots. Legs, unbanded violet, paler at base.

♀—*Head:* shiny black, with narrow-curved scales, of a pale creamy colour with a faint tinge of pale green in some lights; long upright black forked scales and flat pale lateral ones; antennæ black, basal segment globose, shiny, with a few curved hairs; palpi rather long, dark-scaled; proboscis dark, with violet reflections.

Thorax: shiny black, with long narrow-curved scales, the front half with scales of a pale creamy colour, showing pale green in some lights, the posterior half with bronzy scales, except just in front of the bare space before the scutellum; chætæ long and black, especially over the base of the wings; scutellum pale, with narrow-curved pale scales and black border-bristles, four large ones to the mid lobe and several very small ones; pleuræ with patches of pale scales; metanotum deep brown.

Abdomen: clothed with metallic-violet scales, the first segment with dusky scales and long brown fine hairs, the second and following segments with small basal lateral creamy spots; posterior border-bristles brown, lateral ones pale golden to brown; venter dusky.

Legs: uniformly metallic-violet; femora testaceous at the base and below; spines on the femora, tibiæ and metatarsi thick and black; ungues dark, equal and simple.

Wings: with typical *Tæniorhynchus* scales dark; the first sub-marginal cell longer, but no narrower than the second posterior cell, their bases about level; stem of the first sub-marginal cell less than one half the length of the cell; stem of the second posterior not quite one third the length of the cell, posterior cross-vein about twice its own length distant from the mid; halteres with pale stem and fuscous knob.

Length: 5 mm.

♂—*Palpi:* longer than the proboscis, deep violet black, with black hair-tufts with violet reflections, apical segment shorter than the penultimate; antennæ with dark plume hairs. Fore ungues unequal, the larger biserrate, the smaller simple; mid unequal, the large biserrate, the smaller simple; hind equal and simple.

The claspers of the genitalia are of peculiar form (Plate XXXVII., fig. 5).

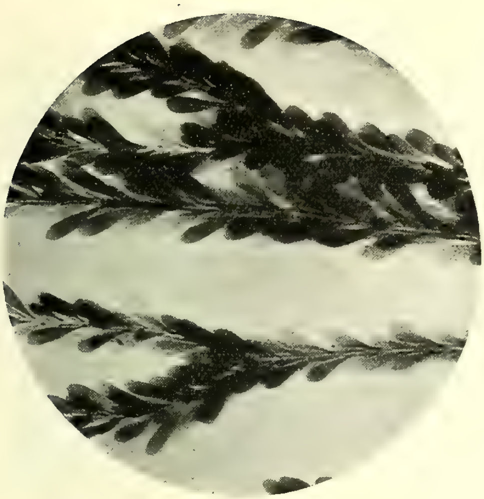
Wings: with rather short fork-cells, first sub-marginal longer and narrower than the second posterior, its stem more than half the length of the cell; stem of the second posterior cell not quite as long as the cell; posterior cross-vein not quite twice its own length distant from the mid cross-vein.

Length: 5·5 mm.

Habitat: Upper White Nile, taken at Taufikia and Kodok. (H. King.)

Observations: Described from two ♀s and one ♂. The bright thoracic adornment and the brilliant violet abdomen at once enables the recognition of this species. The male claspers are very marked.

PLATE XXXIX



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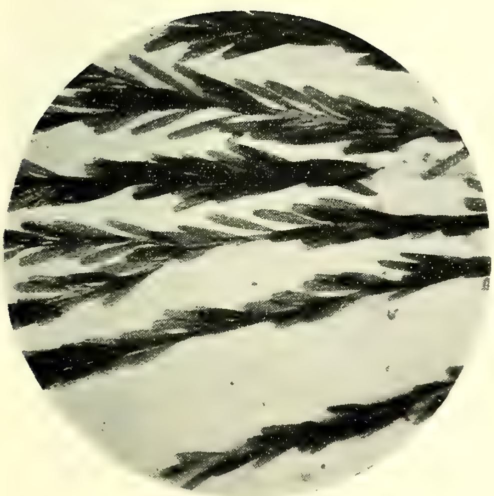

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4

Wing Scales of New Culicidæ

1. Wing scales of *Mucidus sudanensis*, n. sp. (♀)
2. Wing scales of *Culex salus*, n. sp. (♀)
3. Wing scales of *Tæniorhynchus violaceus*, n. sp. (♀)
4. Wing scales of *Mimeteculex kingii*, n. sp. (♀)

Mimomyia circumtestacea

Genus, *Mimomyia*, Theobald
"Mono. Culicid.," III., p. 304, 1903
Mimomyia circumtestacea, n. sp.

Plates XXXV., fig. 8, XXXVII., figs. 1, 2, 4, XXXVIII., figs. 3, 4, and XL., fig. 4

Head: dark brown; thorax, dark brown in the middle, with a pale yellowish testaceous border surrounding it at the sides and front, and to some extent behind. Abdomen brown, with traces of pale spots at the sides near base of segments, most prominent on basal segments. Legs brown. Fork-cells of female wings about same length and width, the stems not quite as long as the cells.

♀—*Head:* deep brown, clothed with deep ochreous brown flat scales and some deep brown chætæ, the scales are ochreous in some lights, two long ones between the eyes; antennæ pilose very long and thin, and deep brown, including the basal segment; second segment of antennæ very long, as in *Deinocerites*; proboscis deep brown, hairy, darkest at the slightly swollen apex, not quite as long as the antennæ; clypeus, deep brown; palpi, very small brown scales, with traces of ochreous reflections towards the tips.

Thorax: deep shiny brown in the middle, with a broad pale yellowish testaceous border around the sides and in front, with scattered small bronzy to brown scales on the dark area, pale ones on the light border; pale chætæ on the pale area, dark on the central area, particularly over the roots of the wings; prothoracic lobes pale; scutellum deep brown, with narrow-curved small scales, five black chætæ to the mid lobe on the posterior border and dark ones on the lateral lobes; metanotum dark brown; pleuræ same pale colour as the border of thorax.

Abdomen: deep brown, with some pale dull creamy scales at the sides, forming more or less irregular basal patches, most pronounced on the second and third segments; border-bristles and other hairs very fine, pale brown to golden brown.

Legs: unbanded, clothed with brown scales, showing dull ochreous and bronzy reflections; ungues small, equal and simple; chætæ deep brown, rather thick.

Wings: with large scales on the apices of the veins; fork-cells moderately long; the first sub-marginal about the same length and width as the second posterior, its base very slightly nearer the apex of the wing than that of the latter; stem of the first fork-cell not quite as long as the cell; stem of the second fork-cell also not quite as long as the cell; supernumerary and posterior cross-veins very slightly longer than the mid cross-vein, the latter about one and a half times its own length distant from the mid; sixth long vein abruptly curved round to the border; halteres with pale stem and fuscous knob.

Length: 3 mm.

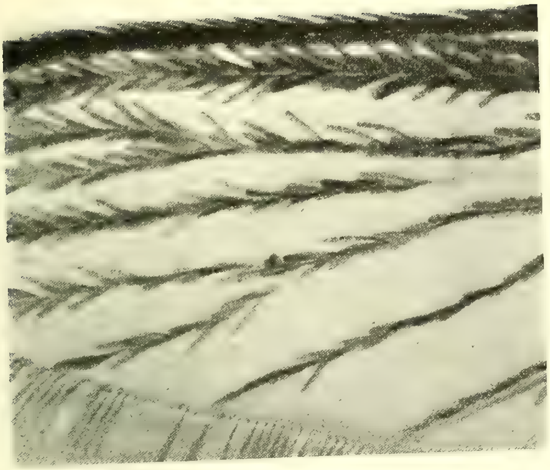
♂—*Head:* brown with brown flat scales, showing dull ochreous reflections and with dull yellowish upright forked scales behind. Antennæ plumose, plume hairs deep rich brown, basal segment black, internodes pale; proboscis deep brown, slightly ochreous at the base; labellæ pale, much swollen along the apical two-thirds; hairy; palpi thin, brown, about two thirds the length of the proboscis.

Thorax: as in ♀. Abdomen with the basal lateral spots more pronounced than in the ♀; pale ochreous ventrally and with pale hairs.

Legs: uniformly brown with bronzy reflections; ungues simple, fore and mid nearly equal in size but slightly different in shape (?).

Wings: with the fork-cells of about equal length and width, the base of the first nearer the apex of the wing than the base of the second; stem of the first fork-cell about as long as the cell; of the second, slightly shorter; posterior cross-vein rather more than its own length distant from the mid. Claspers of genitalia not as long as the basal lobes, rather broad and with a small nearly terminal hook-like segment.

PLATE XL



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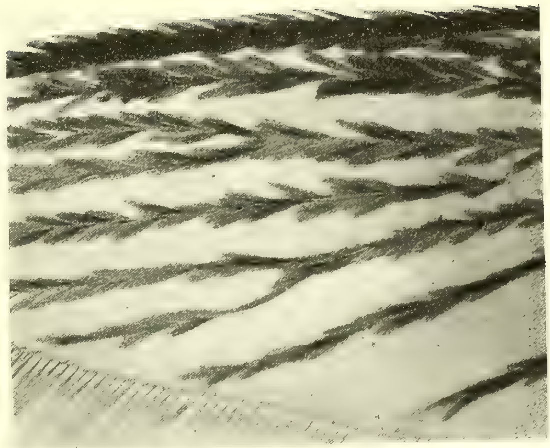

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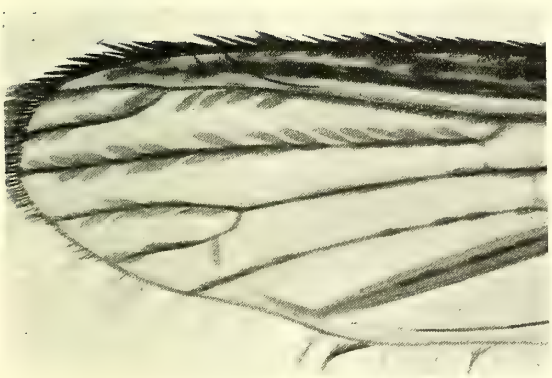

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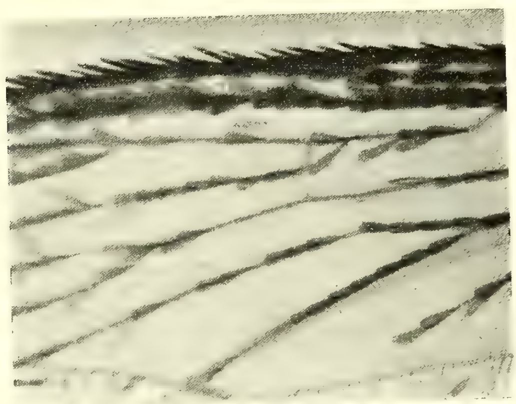

4

WING SCALES OF NEW CULICIDÆ

1. Wing of *Culex salus*, n. sp. (♂)
2. Wing of *Tæniorhynchus violaceus*, n. sp. (♂)
3. Wing of *Uranotænia pallidocephala*, n. sp. (♀)
4. Wing of *Mimomyia circumtestacea*, n. sp. (♀)

Length: 3 mm.

Habitat: Upper White Nile, taken on steamer. (H. King.)

Observations: Described from two males and two females caught by Mr. King.

It resembles to some extent *M. uniformis*, Theob., but can at once be told by the pale area around the central dark area of the thorax and by the wing venation.

The long second segment of the female antennæ I did not notice in *M. uniformis*, but if it occurs it forms a marked generic character.

Genus, *Uranotænia*, Arribalzaga

"Dipt. Argentina," p. 63, 1891; "Mono. Culicid.," II., p. 241, 1901

Uranotænia pallidocephala

Uranotænia pallidocephala, n. sp.

Plates XXXV., fig. 5, XXXVI., fig. 3, and XL., fig. 3

Head: clothed with pale grey scales, looking almost silvery in some lights. Thorax with a white-scaled line extending from the middle of the scutellum to about half across the mesothorax; a white line on each side in front of the roots of the wings; prothoracic lobes white scaled. Abdomen brown, unbanded, with apical lateral pale spots. Legs unbanded, white scales at the base of the first and fourth veins.

♀—*Head:* clothed with flat grey scales, showing silvery white in some lights, some at the back with a dull violet tint; upright forked scales black; antennæ dark brown, basal segment testaceous on the outside; palpi and proboscis brown; clypeus brown.

Thorax: rich brown with narrow-curved bronzy scales; a white-scaled line on each side in front of the wings and a line of white scales extending from the scutellum to the middle of the mesothorax; sides somewhat paler; scutellum paler than mesothorax, with small flat dark scales, some white ones extending on to the mid lobe from the white line in front; four large black bristles to the mid lobe and one small central one; metanotum deep brown; pleuræ testaceous, with traces of pale scales.

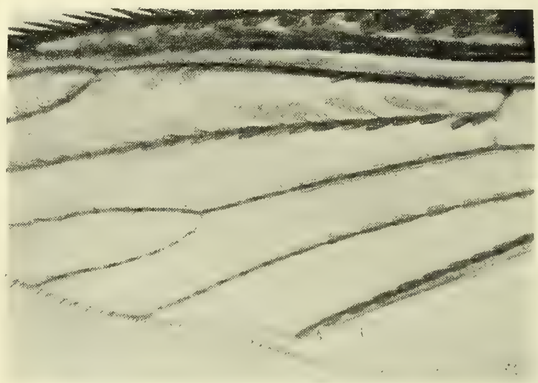

Fig. 55.—Wing Scales of *Uranotænia pallidocephala*

Abdomen: deep brown, with apical lateral pale spots; venter ochreous.

Legs: brown, unbanded; ungues equal and simple.

Wings: with brown scales except at the base of the first long vein and the base of the fourth, where there are lines of flat white scales; large clavate scales on the apical portions of the second and fourth and on all the third; fork-cells small and wide, the first smaller than the second, its base much nearer the apex of the wing than that of the latter, its stem about three times the length of the cell; stem of the second fork-cell about one and a half times the length of the cell; mid and posterior cross-veins about equal in length, the latter more than its own length distant from the mid; sixth long vein broadly curved towards the costa.

Length: 2·5 to 3 mm.

Habitat: Upper White Nile, taken on steamer. (H. King.)

Observations: Easily told from the following by the pale scaled head, and by the wing venation. The head scales show dull purple shades behind in some lights.

The thoracic adornment resembles the next species to some extent.

Uranotænia pallidocephala, sub. sp. *cærulea,* n. sub. sp.
Plate XXXV., fig. 6

Uranotænia pallidocephala, sub. sp. *cærulea*

Very similar to the former (*U. pallidocephala*), but the head bright violet-blue, as in *U. cæruleocephala.*

♀—*Head:* clothed with bright violet-blue flat scales and a few upright black forked scales, black chætæ, two long ones close together projecting between the eyes; eyes silvery; antennæ brown, basal segment testaceous, slightly darkened on the inner side; proboscis and palpi deep brown.

Thorax: pale brown, with scattered narrow-curved bronzy-black scales and blackish chætæ; a line of white scales on each side in front of the wings, and one running from the scutellum to the middle of the mesonotum; prothoracic lobes, with silvery white flat scales; pleuræ dark above (forming more or less of a dark line), pale testaceous below, with some flat silvery white scales; scutellum with small flat black scales; metanotum pale brown, with a median dark line.

Abdomen: dark brown, with violet reflections and with apical lateral pale spots on the last few segments, pale dull golden to brown border-bristles and pale-scaled venter.

Legs: dark brown, with a dull metallic coppery tinge; ungues equal and simple.

Wings: with brown scales, except for a line on the base of the first and fourth veins, which are shiny-white; first sub-marginal cell shorter and narrower than the second posterior cell, its stem not quite three times the length of the cell, its base nearer the apex of the wing than that of the second posterior cell; stem of the second posterior cell about one and a third times the length of the cell; posterior cross-vein slightly longer than the mid, about its own length distant from it, and sloping towards the junction of the supernumerary and second vein. Halteres with grey stem and fuscous knob.

Length: 2·8 to 3 mm.

Habitat: Upper White Nile, taken on steamer. (H. King.)

Observations: Described from four ♀s. It may be only a sub-species of *U. pallidocephala,* but the constant bright violet-blue head and the different cross-veins make it possible that it is a distinct but closely allied species.

Until ♂s can be examined, and more is known of the bionomics of these two *Uranotænia,* it is best to treat it merely as a sub-species.

Fig. 56.—Burun, with peculiar skin affection, possibly leprous

The Healing Art as Practised by the Dervishes in the Sudan during the Rule of the Mahdi and of the Khalifa

BY

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(Translated from the Arabic)

The Surgical Facilities possessed by the Army of the Mahdi and the Khalifa

Surgical measures

Surgical measures were at first wholly carried out by men termed *El Busara*, this being the plural of *Bassir*. To no other physicians were surgical operations entrusted until about the period when the Mahdi died. I was the Medical Officer at Khartoum, and several others were associated with me under the old Government in medical and surgical work during the siege. There were also certain dispensers, some Greek merchants, who possessed drugs, as well as certain Austrian priests—Father Ohrwalder for instance, and a few nurses.

The *Bassir*

In addition to the *Bassir*, or medicine man of the Dervishes, there existed the *Hallag*, or barber-surgeon, and the *Daia*, or midwife, a more or less trained woman who attended to obstetric and gynæcological cases.

The *Hallag*

The *Daia*

The *Bassir* was considered the wise physician, and was entrusted with the compounding of medicines. Very often he possessed considerable knowledge, but he took care to secure his fee before prescribing, and too often his "cures" were a mixture of savage quackery and charlatan tricks. The *Hallag*, who did not possess any special technical knowledge, was nevertheless regarded as a practical workman and was a familiar figure with his razor, bleeding-horn and circumcision clamp. It was the fashion to be bled once every six weeks, so that the barber-surgeon was kept busily employed.

General Surgical Technique

Wounds

When a person was wounded by bullet or sword he came under the care of the *Bassir*, who, if the wound was a simple one, washed it with water and applied ground coffee to arrest hæmorrhage. In cases where there was no bleeding native butter or boiling tallow was employed, with or without the subsequent application of gunpowder. The wounded part was then bandaged with calico and dressed daily. Before complete healing took place the wound was exposed to the air to dry without the application of any medicament.

Fractures

In cases of wounds complicated by fracture of bone it was the custom to set the fracture, to wash the wound, and to dress it with butter. In inflammatory cases a butter bath was in vogue. "*Jareed*," the ribs of the compound palm leaf, were used as splints. A simple fracture of the limb used to be kept tied up for forty days. It was then examined, and if healing had not taken place the splints and rags were again applied. If healed, the part was massaged with ostrich fat. Gangrene, from over-tight bandaging, was by no means rare. The *Bassir* usually preferred to allow a foreign body to work its way out. Indeed, most of the natives objected to the operative attentions of the *Busara*, preferring death to bungling.

From the account of Mohamed Nur-El-Barudi, who accompanied Wad-El-Nejumi on his march towards Egypt and was present at the battle of Toski in 1889, it appears that the wounds caused by modern weapons and projectiles were treated with an ointment made of beeswax and sesame oil and were then covered with cotton (*damoor*) lint. This dressing was changed every twelve hours, but the wounds were not washed, merely wiped with cotton wool or damoor. When a bullet lodged near an artery or vein, a small piece of lead (*sic*) was placed on the wound in order that the lead outside might corrode the lead bullet inside. Bullet wounds where the bullet completely perforated the part without effecting a lodgment were filled with honey in order to exclude the air.

Amputations

Amputations as conducted by the Bassir

The limb to be amputated was stretched out of an opening in the wall of the dwelling or out of a window by the assistant, the latter standing outside and to the right of the limb. A pillow was placed under the limb and then the *Bassir* severed the latter with one stroke of a sharp sword. The stump was at once plunged into boiling oil and hæmorrhage in this way speedily arrested. A bandage of calico was applied and after three days a first dressing with butter was carried out. The wound was then dressed daily until it had healed or until death supervened—no uncommon occurrence. Of course, no anæsthetic was employed, and in some cases the person undergoing the operation was expected to render help to the *Bassir* by handing him instruments, etc. He was also expected to repeat the prayers of the Mahdi, and was taught to believe that all these ills of the flesh were intended to happen, and that they must be considered as cause for rejoicing. The Mahdi issued proclamations to this effect. Some of the patients were exceedingly stoical and endured the pain and wounds without a murmur.

During convalescence, especially in the case of fractures, the *Busara* advised the patients to eat dates, said to be the most useful diet for promoting union of bone. In case of delayed union they were wont to assert that failure was due to an insufficient quantity of dates having been eaten.

Medical practice

Medical Practice

Some of the natives were clever at diagnosis, while the treatment of various diseases presents points of interest which will now be mentioned.

Respiratory diseases

Respiratory diseases. Bronchitis and cough were treated with ground, torrified dura (millet), prepared like a decoction of coffee and termed "Galiya." The flowers of "*Karkade*" (*Hibiscus sabdariffa*, Linn.) were also employed. The plant grows abundantly in the Sudan and has purple flowers. From these an infusion was prepared which possesses a delicious taste. It was given hot and sweetened with sugar. The Sudanese believe "*Karkade*" to be one of the plants of Paradise. In pneumonia, venesection was practised. Headache and migraine were often treated by giving liquid tallow. This was drunk or poured up the nose, a funnel being used to facilitate administration. This, the method of El-Tasfeeh, possessed a great reputation.

Fever

Fever. In ordinary febrile attacks massage was employed, a mixture of vinegar, henna and common salt being used as the lubricating agent, and, at the same time, a purgative in the shape of senna or tamarind was administered. Occasionally *El Karad*, the fruit of *El Sant* (*Acacia albida*, Wel.), was ground and placed in the patient's bed.

Chicken-pox

Chicken-pox (*El Burgum*) was lightly considered and treated by a senna purge and the application of mud to the vesicles. The patient was not allowed to have a bath until a week after the termination of the disease.

Smallpox

Smallpox. This disease was, and is, dreaded by the natives, especially the Arabs, who know and fear its sequelæ. When quarrelling amongst themselves a common term of opprobrium is "infected with smallpox." On the appearance of the rash the patient was at once isolated, being removed to a place two miles distant from any populous neighbourhood. There he was placed in charge of an attendant, who had previously had smallpox, and whose duty it was to give him onions, milk and native bread (*Medida*). Despite a considerable period of isolation, the disease used to spread owing to lack of vaccination. There was a severe epidemic in 1885 when Omdurman fell into the hands of the Dervishes. About twelve thousand people are known to have perished. But little attention was paid to cases of measles and typhus fever, the natives being very careless about them.

Colic. For colic a decoction of Hargal (*Solemnostemma Argel*, Hayne) was used or the powdered leaves given mixed with native bread, *i.e.* dura meal boiled with water. One dose was usually sufficient, but sometimes two or three administrations of the drug were required. Colic

Diarrhœa. Many drugs were in vogue for this common complaint. "*Karad*," already mentioned, was often tried, but *Ardeb*, tamarind (*Tamarindus indicus*, Linn.), was in greater favour. Diarrhœa

When the two were combined, half an oke = 0·624 kilo of each, was put into a quantity of water and the mixture allowed to stand for twelve hours. Then it was drunk in three doses. The medicine was repeated for two or three days if necessary. Thereafter, if the patient had improved, galls (*Afus*) and pomegranate bark were exhibited. If dysentery occurred two dirhems = 6·24 grammes of Tartus was boiled in a rotl = 450 grammes of water and drunk in one day.

Infantile diarrhœa, in young children, was often treated by extracting the teeth and scarifying or burning the sockets.

Eye diseases. In ophthalmia cataplasms of green powdered *sant* leaves made into a paste were applied. If benefit did not result, alum mixed with white of egg was substituted. The Falatah, who came from the neighbourhood of Darfur, were wont to practise needling in cases of cataract. This operation has long been known amongst this tribe, and the immediate results of the procedure were as a rule satisfactory. Eye diseases

Gonorrhœa. The roots of *Rabah* plant (*Trianthema pentandra*, Linn.), which grows on Tuti Island near Khartoum, had a great reputation in cases of gonorrhœa. They were dried in the sun or before a fire, powdered, and about two dirhems of the powder were mixed with *marissa*, the native beer brewed from millet, and taken in small quantities. The effect of *Rabah* roots was to cause an inflammation of the genito-urinary tract. When this ensued, as evidenced by the red colour of the blood-containing urine, the patient stopped taking any more of the mixture. In some instances the inflammation vanished and the disease disappeared with it, in others the irritation increased and retention of urine resulted. When this occurred the patient was immersed in a warm butter bath, and if this measure failed resort was had to the catheter.[1] Not infrequently the patient died unrelieved. Gonorrhœa

Another method of treating gonorrhœa consisted in the administration of "Atrum" (natron). Two dirhems of this were taken and burned until it became whitish-red, then it was powdered and mixed with a quarter of a rotl of liquid butter and the whole quantity drunk at one time. This medicine acts as a purgative and diuretic, and in mild cases appeared to do good.

Syphilis. This was treated in many different ways. *Tureba*[2] was used. This is a kind of powder, a heavy salt having a taste similar to Epsom salt. It produces copious diarrhœa. Syphilis

[1] The catheter commonly used by the natives of the Sudan is the quill of a turkey's feather. It is carefully cleaned of down or small feathers, is then smeared with fat and gradually passed into the urethra. A little of the grease is poured into the quill and this is continued till the urine flows. I am indebted for this note to Mr. Macduff Simpson, of the Gordon College.—A.B.

[2] *Vide* Second Report, Wellcome Research Laboratories, p. 237.

A glassful of the powder was put into an earthen jar and three pounds of water were added to it. Twelve hours after this the solution could be used. The patient took a glassful every morning before eating and he continued to do so for a week. The accompanying dietary consisted of unleavened, unsalted bread (*Kissera*), and this reducing fare was taken for three weeks. Sometimes fifty dates were put into the *tureba* solution, twenty-five being taken in the morning and the remainder in the evening.

If these measures failed, resort was had to *Ishba* (Sarsaparilla). The plant was powdered and mixed with an equal quantity of sugar. An ounce of the mixture was taken twice daily. Sometimes it was used as a paste made up with honey and pepper, at other times a syrup was manufactured. During its administration certain rules had to be followed. The patient had to live apart. A servant (always a very old woman) was assigned to him. He was forbidden to communicate with others. His diet was to consist solely of Kissera. He must not give way to anger. This isolation was continued for forty days. If after this there was no improvement the sarsaparilla was to be repeated for another week. Thereafter a fumigation with talh (*Acacia seyal*, Del.) wood was carried out.

Snake bite

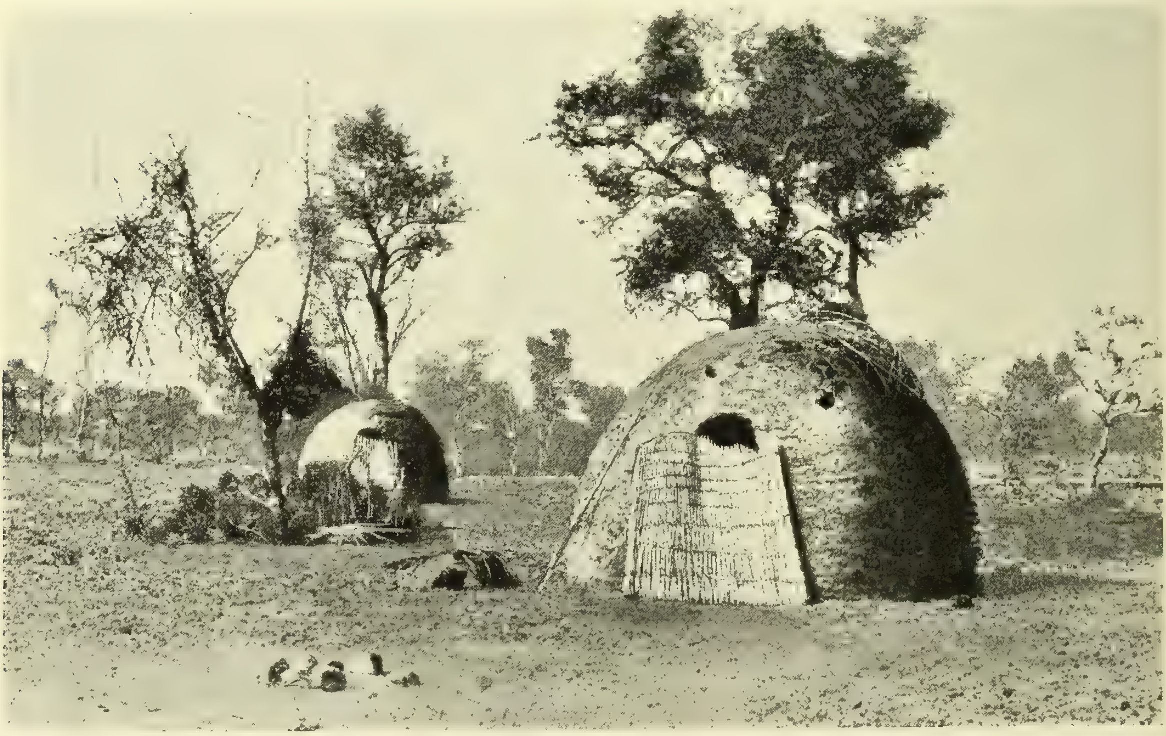
Snake bite. The point of puncture was incised, cupped or burned and then a "Dilluka," native gathering of people, was maintained for twenty-four hours with singing and beating on tambours to prevent the patient from falling asleep. It was thought that if he slept he would infallibly die.

He was also made to drink hot native tea and was fumigated to incite free perspiration.

The root of a plant, "Erg-El-Dabib," was also applied to the bitten part.

Scorpion bite

Scorpion bite. After bleeding or burning, powdered "Erg-El-Agrab" was applied to the affected part.



A. MacTier Pirrie

Fig. 57. Shilluk Huts

The Native Methods of Treatment of Diseases in Kassala and Neighbourhood

BY

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Surgical Instruments

No special instruments are in vogue, the ordinary dagger being employed to open abscesses, etc.

The use of the actual cautery is extremely common, but the natives have no special instrument, large packing-needles usually being employed for this purpose.

Splints

Splints. Special splints for fractures do not exist, but splints are very cunningly made from the bark of trees, when required; I have seen two cases of fractures put up by natives, the bark being evidently chosen for the size of the limb, excellently padded with grass and tied up with strips of old cloth.

Blisters

Blisters. Are stated to be unknown—actual firing only being employed.

Dressings

Dressings. None, only ordinary cloth.

Methods of Treatment

Wounds and ulcers

Treatment of Wounds and Ulcers. Stitching up wounds is apparently unknown.

Ulcers and wounds are treated either with

(1) Ashes from burnt wood, or

(2) Fresh cow-dung mixed with hot water made into a poultice and renewed every 24 hours.

Fractures

Fractures. These are fixed by improvised splints made from bark, boughs or dura stalks, padded with grass or leaves and bandaged up with strips of any old cloth.

No medicine is given, but the natives consider it imperative to eat the flesh of chickens, if their means allow; if not, ordinary meat, with kissera[1]—other forms of food being avoided.

The flesh of the fowl is considered by them to have wonderful powers of uniting and strengthening broken bones.

If there is a single fracture of the humerus they keep the splint in position fifteen days, if it be broken in two places they double the time.

Fractures of the thigh are kept in splints 40 days.

After removing the splints, massage with any available oil is the usual proceeding.

Dislocations

Dislocations. The first procedure is to bathe the part with hot water, then reduction is attempted by straight pulling; apparently the foot in the axilla is never used for shoulder, nor the knee on the arm for elbow dislocations.

It is then bandaged up and perhaps splints may be employed; usually the bandages and splints are removed in five or six days.

Sometimes, when the thigh is dislocated, pegs are driven into the ground and the patient bound to them, so that the legs are immovable; he remains in this position for seven to nine days.

This treatment is not employed if they consider the bone is broken.

Guinea worm

Guinea Worm. They poultice the swelling with either

(1) Hot poultice of cow-dung, or

(2) Poultice made of Tum (a small bulb, like an onion) mashed up in hot water.

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[1] Kissera = unleavened dura cake.

When the worm escapes they either

(1) Wind it round a small piece of wood, winding a little more each day, or

(2) Tie a piece of thread round the worm and then round the limb to prevent the worm retiring.

Diseases of the lungs

Diseases of the Lungs. Phthisis, pneumonia, broncho-pneumonia, bronchitis, etc., are all regarded as identical, but the native knows from experience that expectoration of blood continued for any time is serious; they have no idea that the expectoration is infective in phthisis.

They employ for all kinds of coughs

(1) Karkade,[1] apparently the petals and sepals of a pink flower, in a dried condition. A small handful is made into an infusion and drunk.

(2) Hazambal, a root, stewed with sugar and taken like a sweet.

Dysentery. Treated by either

(*a*) a diet composed entirely of a soup made of onions, or

(*b*) opium made up as a suppository with fat or oil and placed in the rectum.

Leprosy

Leprosy. Recognised as an incurable and infectious disease. Isolation is often insisted on and no drugs are given.

To induce Pregnancy. A special *Hegab* (charm) is worn. If a woman become thin and in poor health she takes *Gongalace,*[2] apparently a powdered grain (like dura flour), a handful being placed in hot water and then drunk. This they consider makes them fat and produces large breasts.

To prevent Pregnancy, or cause Abortion. They squeeze the milk from the Dead Sea apple fruit,[3] place it on cotton wool and deposit it in the vagina.

To increase Sexual Power in the Male. Many drugs are taken, especially haschish and opium. However, the penis of the crocodile eaten with spices is considered to be the most potent of all in this respect.

Syphilis

Syphilis. They recognise the contagiousness of this disease, and in the male connect the primary sore with the subsequent manifestations; this knowledge has apparently existed for a very long time. It is considered that the male with sores on his penis or eruptions on the body may convey the disease to the female; the female may convey it to the male if

(*a*) she has outward and visible signs of the disease;

(*b*) if she only has it "internally," then contagion occurs solely if copulation takes place during the menstrual period.

Treatment. When infection is apparent, even as the primary sore, *Eshba* (Sarsaparilla) is pounded up in hot water, and some of the infusion is drunk night and morning. This treatment is continued for a week, and during this period patients must not eat or drink tea, coffee, salt, pepper or vegetables, but their diet consists of honey (especially) sugar, meat and kissera (made without salt).

The natives hold that smoke from a fire greatly aggravates the disease, but if they are drinking the Eshba the fumes are harmless.

If the disease is in a virulent form, *Kunsh* (a spice) is added to the treatment, and the patient is kept in a closed tukl, the light being excluded from the dwelling, and the door being only opened to allow of the admission of food.

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[1] *Hibiscus sabdariffa,* Linn. Red Sorrel of West Indies.—A.B.

[2] This is probably *Gongoleise,* the pulp surrounding the seeds of the "Cream of Tartar tree," *Adansonia digitata.*—A.B.

[3] *Calotropis procera,* Ait. The Ushar plant.—A.B.

This treatment is maintained for 40 days, and usually a very old woman is the sole person allowed to wait on the patient.

At the end of the 40 days he should be cured; if the disease be still present, they consider that he will die.

A finely-divided brownish-black earth termed tureba[1] is sold in the *Sûk* for syphilis.

This is said to contain mercury, and is supposed to come from a place near Goz Regeb, on the River Atbara.

About one ounce of this earth is taken every night with milk seven to ten days running.

They have the idea that a woman once infected, though apparently free from the disease, may transmit it to her children; but if a considerable time has elapsed since she has shown active symptoms of this disorder, and if care be taken not to wash the child born of her with water for 40 days after birth, then it will not develop symptoms of syphilis.

Gonorrhœa. The native considers this disease may arise from the following sources:— Gonorrhœa

(1) A woman—though she may never have had connection with another man.

(2) Direct heat of the sun.

(3) Walking with bare feet on hot ground.

(4) Riding horse, donkey or camel.

(5) Nocturnal emissions they consider to be a sign of gonorrhœa.

They know that the condition is infectious, but impose no punishment on the transference of the disease. They have two methods of treatment:—

(1) Mahlab (small grain) crushed and put in marissa—taken daily for a week.

(2) Roots from a tree (name not ascertained)[2] mashed up with marissa and taken daily for a week. Marissa is considered good on account of its producing copious urination. It is the native beer prepared from dura (millet).

Flatulent Gastritis—Drugs used:— Gastritis

(1) Shau[3]—small quantity, as on 10 piastre piece—followed by a large drink of water.

(2) *Hargal*[4] (small leaf of a tree). Handful made as tea.

(3) Dirh (small seed).

Colic. Reshad—tablespoonful in milk. Colic
(Small reddish-brown seed.)

Worms. Type of worm not ascertained—probably *Tænia solium*. Worms
Shau—dried flower on stalk, infusion of one ounce.

Inducing Uterine Contraction. Haza—small dried yellow stalks. Handful made as a decoction.

Snake Bite. Excision of part wounded, or free opening with a knife. Snake bite

Proximal ligature of the limb—this is often kept on for 24–36 hours, and I have seen a case with very extensive gangrene owing to this being maintained for three days.

They have an idea that if the snake be killed and its head is tied on to the limb above the wound, that this will prevent dangerous symptoms. This procedure I have seen carried out in one case, and the proposed removal of the dead head of the snake was strongly objected to, great satisfaction being shown when the head was permitted to remain tied on to the limb.

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[1] *Vide* Second Report, p. 237.

[2] Probably rubah root, Rabáa or Rabah (Arab.); *Trianthema pentandra*, Linn.—A.B.

[3] The Mustard Tree—*Salvadora persica*, Garcin.—A.B.

[4] *Solenostemma argel*, Hayne.

A. MacTier Pirrie

Fig. 58.—Trial by British Magistrate

A. MacTier Pirrie

Fig. 59.—Trial for Adultery

Additional Notes

contributed by

Sir Rudolph Baron von Slatin Pasha, K.C.M.G., C.B., C.V.O.

Inspector General, Sudan Government

H.E. the Inspector General, Sir Rudolph Baron von Slatin Pasha, kindly furnished me with some notes on native methods of treatment derived from his own extensive experience of Dervish customs, and from information furnished by one of the more reputable native Hakims. Certain of these methods have been fully detailed in the foregoing papers. Here we only insert such as have not received mention and any special points of interest. Sir Rudolph was unfortunately prevented by illness from completing his contribution.

Syphilis

Before taking breakfast the patient should be given $\frac{2}{3}$ rotl of milk and $\frac{1}{3}$ rotl of butter, all mixed with one ounce of burnt natron. This has to be continued for three days. Treatment of syphilis

After this $\frac{1}{4}$ rotl of pure honey should be mixed with $\frac{1}{3}$ ounce of green tutia (?) and given him daily before breakfast for three other days, if the constitution of the patient is strong; otherwise the "tutia" should be reduced to 3 or 2 dirhems.[1]

During this time the body should be washed and perfect cleanliness observed; the diet should consist of beef, onions and vegetables; sexual intercourse should be avoided.

After this, "Kunsh" wood should be made into powder and boiled over the fire; the patient should drink of it twice a day, each time consuming $\frac{1}{2}$ ounce in the morning and evening. It should be taken hot. While it is being prepared the patient should bend his head over its vapour, and this has to be continued for six days. During this time his diet should consist of white dura or maize (dura Shami), prepared without any salt. Faterita dura should not be used. The loaves thus prepared should be consumed with water five or six times a day, for a period of six days also. This unsalted bread is to be eaten with the broth of mutton, no onions or salt to be used, yet some pepper may be mixed with it. This has to be continued for another six days.

During the fourth period of six days, the bread may be prepared half-way between leavened and unleavened and half salted. No onions whatever during this time. The patient should also be fumigated with the wood of the "Talh" tree (*Acacia albida*).

After this treatment the patient becomes completely cured!

As regards the "tureba" treatment, it is said that no other medicine is so effective for syphilis because our forefather Adam was made of earth!

Gonorrhœa

1. Take 5 rotls of helba (this is given by Broun as *Trigonnella Foenum-græcum*, Linn., but Sir Rudolph refers it to another of the Leguminosæ, *Argyrolobium Abyssinicum*, Janb. et Spach.) and boil them well with 30 rotls of water until the essence of the helba is dissolved in the water. When the infusion is tepid the body should be submerged in it, and this medicinal bath repeated for three days. Treatment of gonorrhœa

[1] A dirhem = 0·11 oz.; 9 dirhems = 1 oz. practically.—A.B.

2. Black tea should be boiled and half sugared. Then it should be placed in an open vase and kept in the open all night. The patient should drink of this for seven days. Cure may take place in a shorter period.

Dysentery

Treatment of dysentery

1. Grind $\frac{1}{4}$ rotl of wheat and $\frac{1}{4}$ rotl of helba, and boil them with 2 rotls of cow's milk. The mixture is to be taken warm after 1 ounce of butter and 1 ounce of sugar have been added to it. The patient should then be heavily covered until he perspires freely. If necessary the treatment can be repeated.

2. Mix the flour of white dura with sour milk and make a dough of it (using no water). Eat this in the morning, adding some cream from the sour milk and some sugar. Continue treatment for three days. Avoid drinking cold water and eating meat.

3. Eating the liver of camels dipped in citron and salt is highly esteemed.

Boiling Blood

The term used to denote plethora

Treatment—

1. Boil in three separate vases each of the following medicines: "Kurkum" (Saffron), "Kurunful" and Oud om Abiad. When they have been well boiled drink a cup of each. The result is free purgation.
2. An infusion made from the bark of the Sunt tree may be drunk, used also for rubbing the body.
3. "Karkade" is also employed, taken with sugar like tea.

Headache

Treatment of headache

If the headache is felt with some lightness in the head and humming, it means some irregularity in the head and body, and in this case goat butter should be snuffed, the head rubbed with it, and some sugar taken with water.

If the headache is caused by the sun or is due to influenza, the "Kab" salt (from a place in Dongola Province) should be melted in red vinegar, and placed on the head after shaving the hair.

If this salt is not procurable, ordinary salt may be used.

The following is given in the words of the Hakim. It is impossible to recognise the illness he describes:—

"Dabas"

The disease called "Dabas"

This illness is a sort of influenza which prevails in the Sudan, and very few escape from it. If the attack is serious, the sight or teeth are usually lost. It occurs sometimes during the winter, but oftener in summer time.

Headache and swelling of the skin are among its general symptoms, and bleeding or purgatives produce no benefit because the illness is caused by the uncleanness of the blood inside the arteries and not the exterior blood of the skin, which could be taken off by means of cupping. It often causes swelling in the lips, throat and face.

The best remedy is to snuff the fat of the fox and rub the skin with it. Another good remedy is the bark of the "Arak" tree (*Salvadora persica*, Garcin), which, after being reduced to powder, should be mixed with water, made into paste and placed on the head for one minute or more if possible, because it is painful and unbearable. (This is the so-called Mustard Tree.—A.B.)

Another Remedy.

Press out the juice from radish leaves and keep in the mouth for three or five minutes. Add to the leaves already pressed out malt vinegar and keep in the wind until it becomes cold as ice, then cover the face and head with it. Trials have proved its great benefit.

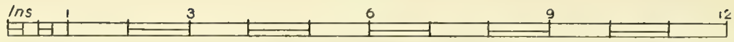
Neuralgia

Pound the black Cumin (?) and add to it goat's butter. Leave in the sun until it melts and then clean and use by the method of snuffing. This is effective when the pain is caused from heat or trouble in the brain, but if it is caused from "Dabas" the treatment already described should be used. Sometimes the pain may be caused by toothache. Treatment of neuralgia

If the pain is serious and threatens to injure the eye, the well-known triangular magic ring known as "Khatim-El-Batta" should be used, but this requires faith and good belief!

FIG. 60.—NATIVE HUT, BURTA TRIBE, JEBEL KEILI

PLATE XLI



CHARMS: KETA'B, HEGAB, OR WARAGA. *(See pages* 284–290*)*

1. A charm against the evil eye and evil spirits, compiled by one of the physicians to the late MAHDI and presented to me by his son
   The square case contains the KETAB or written charm; the small sack a preparation of roots (composition unknown)
   This charm is designed to wear round the arm above the elbow. As also Nos. 2, 3, and 4
2. Written. For desires to be fulfilled
3. Written. Against the sting of scorpions
4. Three written charms designed to cause impotence in others. One is buried in a neighbouring grave; the other two being secretly laid under the subject's bed
5. Written. Against headache
6. Written. Against toothache
7. Written. Against headache
8. A Love amulet. Four written charms, two worn on a level with the breasts; two on a level with the hips. Designed for suspension round the neck. As also Nos. 9 to 15
9. "3 Papers." A love charm
10. CHARM against the EVIL EYE. One case containing a written paper, the second some herb (?)
11. CHARM AGAINST REPTILES. One leather case containing KASIRASWIL root. The other containing a circular disc of WARAL skin (the Lizard IGUANA)
    Used as a prevention and cure against the attack of reptiles. In cases of snake bite, the wound is "freshened" by being briskly rubbed with the lizard skin, and then cauterised with the charred end of the root
12. Stones from the grave of a Holy man for protection from illness and evil, and to bring good luck
13. CHARMS AGAINST SNAKE BITE. One written, the other a root (?). Designed to be worn round the neck
14. Two written charms for love
15. A false charm, made for a woman, very bulky and containing only wooden blocks instead of genuine charms

Medical Practices and Superstitions amongst the People of Kordofan

THEIR TREATMENT OF DISEASE AND THE CHIEF DRUGS, INSTRUMENTS AND APPLIANCES IN COMMON USE

BY

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Medical Superstitions

The superstitions of the native are so many, so varied, and, at times, so vague, that it is difficult, from a medical standpoint, to gain even a superficial acquaintance with them, the more so since the Arab is naturally loth to impart to an unbeliever the intimate knowledge which so closely concerns his own person and his religion. Again, too, the borderline between purely medical and general superstition is absolutely indefinite, and both are so intimately blended with religious rite that it is impossible to touch on one without encroaching on the other. In the following notes, therefore—which deal more particularly with the customs based on the religion of the Arab, Mawalid and Falatah inhabitants of the larger towns rather than those of the more rural semi-Mohamedan Nuba, who has adopted along with his borrowed religion many of its superstitions, at the same time retaining those of his own—I fear there will be found much irrelevant matter, with often no more sound foundation for facts than the gossip of a people who exist in a perfect atmosphere of the supernatural. Introduction

This atmosphere, in which the dread of ever present evil, seen and unseen, emanating from man, ghost, and devil, is far from counterbalanced by their faith in a more distant deity and fanatic belief in the supreme power of holy writings, the which however seem to require for their efficiency the mysterious mutilations, arrangements and additions of holy men, often themselves illiterate and more often than not gross impostors. Such men do, indeed, occasionally combine the more worldly use of drugs with their spiritual cure. These drugs hold a very secondary place in their practice however, falling more within the sphere of the ordinary Hakim, yet even in his methods this vein of superstition and fatalism is predominant. Superstitious atmosphere

Propitious days are selected for the commencement of various cures, which are limited to a fixed period, resulting "An Sha'a Allah" in success or failure. There are defined courses, certain prayers, and a special attention to unnecessary minutiæ of diet, mode of life and regimen, whilst the mere strength, dose, and preparation of their specific, usually drastic, medicines are left largely to chance. Again, where the Hakim fails the Fiki[1] is called in, or, indeed, the two may join together to combat ills spiritual and bodily. Under these circumstances the Fiki, at any rate, thrives, conducting a busy trade in the sale of Ketabat, the working of sorceries, and the offering up of prayers for freedom from the attack of disease, real, imaginary, present or impending, from inflictions of the powers unseen, and the dire effects of the evil eye of man, which petty annoyances so materially complicate the already intricate national existence. Forms of cure The Hakim and the Fiki

To the native, in his complete ignorance and credulous faith and fear, no process is too absurd for belief, and often, within his limits, no price too high to accomplish a cure. I have met with patients suffering from chronic disease who have been financially

[1] The Hakim may be regarded solely as a medical man, having no dealings in the scriptural or supernatural. The Fiki, on the other hand, is a religious Ascetic who encroaches on medicine only in prayer, occult charm, incantation, and the like.

ruined in their endeavours to regain health at the hands of holy men. One had spent fifteen years with its hard earned wage hoping for the miraculous extraction of a 3 oz. vesical calculus, subsequently removed by operation; whilst a woman had endured seventeen years of poverty, trusting to be eventually delivered of a child which insisted on living *in utero* throughout this period! Nor among a people whose theory of disease is based entirely on supernatural visitation can one expect otherwise; thus it is, indeed, that all types of malady fall within the scope of supernatural cures. The native not unnaturally considers, and is encouraged to do so, that prevention is better than cure; he therefore purchases and wears a collection of preventive charms and safeguards, and in like manner his children from their earliest years. One will seldom find an Arab who does not carry at least a talisman against the evil eye, another against evil spirits, and one or two having to do with love.

Causation of Disease.

Beliefs bearing on the etiology of disease

Taking into consideration, under two comprehensive headings, the chief factors which (from a native standpoint) bear on the production of disease, we have in the first place:—

The Evil Eye—probably the commonest cause of malady, and one greatly dreaded by these people; the late Khalifa himself being, I believe, particularly superstitious in this respect. It may be acquired or hereditary, more usually the former, in which case persistent jealousy and ungratified covetousness have gradually "poisoned the glance," so that all persons, animals and even things looked upon are harmed, to a greater or lesser degree. The possessor of such an eye is termed "Sahar," an Evil One. He is soon detected and avoided, local calamities are attributed to him, and he not infrequently falls under the hand of the law. Being, as a rule, banished from place to place, he becomes an outcast among men. Some are said deliberately to acquire the evil eye for the power it gives them of inflicting trouble and disease on their enemies; others are content to buy the services of a "Sahar" for such an end, whilst childless wives possess almost unknowingly this evil influence over the newly married and their offspring, expected or produced. The detection of the evil-eyed is a matter of great difficulty. They are generally "known by their works," they are often evil looking and reclusive, keeping their eyes downcast and considerately neglecting to look one in the face, whilst in conversation they omit to make pious reference to the name of God. There is apparently no sign manual, as in the south of Europe, for protection against attack. One can, however, ward off the individual and his glance by pointing at him a piece of long white bone, covered at the pointing end with soot, which seems to bear a relation to the universal "crescent moon" or "horn" charms of other countries, and is designed to concentrate the attention of the evil eye. Children, who are most susceptible, wear round their necks—

The Evil Eye

Charms against the Evil Eye

1. El Abu Abyad, or Ababyad (Plate XLII., fig. 11)—a charm consisting of two pieces of "wad abiad" (67) suspended one above the other in a strip of leather.

2. El Goza (Plate XLII., fig. 12)—a pair of Heglig[1] nuts, similarly placed.

3. El Hafiza (Plate XLII., fig. 9)—a large disc of silver about 2 in. in diameter, on which is inscribed "Protector! Protector! protect our little Ali" (or whatever the child's name may be), whilst both adults and children carry also specially prepared written charms, to which I shall refer later. For cure as well as prevention there are certain highly considered roots:—

Preventive and curative roots

1. El Shari (?), which in cases of necessity must be chewed to a pulp in the mouth (preferably of a holy man), and applied to the interior of the nostrils of the sufferer, who sneezes violently many times and is then greatly relieved or even cured.

[1] The fruit of *Balanites ægyptiaca*, Del.

PLATE XLII

CHARMS. *(See pages* 288-292*)*

1. EL BARAD (cold).—An opaque white stone worn round the wrist in order to protect the wearer's horse from horse sickness
   This stone is supposed to fall with the hail, hence the name
2. EL HAGAR ET DAM (blood stone)—Mounted as a ring
3. EL HAGAR ET DAM—Used as a neck ornament
   Placed in water, which is then used as a specific in cases of sunstroke and headache. In epistaxis, one of these stones is tied round the forehead to check the bleeding
4. EL HAGAR EL AKHDAR (green stone)—Mounted as a ring
5. EL HAGAR EL AKHDAR—Roughly cut as a neck ornament
   The stone is placed in boiling water, which when cool is administered locally and internally in cases of sunstroke and headache. The stone also acts as a styptic when locally applied
6. EL FEROUS (turquoise). Worn set in a ring. Placed in hot water, which is then drunk to relieve vesical retention. Looked at the first thing in the morning it brings good luck for the rest of the day
7. KADUG.—Horn fitted with a root (?) for protection against wounds
8. A spurious written charm
9. EL HAFIZA (protector)
   A silver charm suspended round the necks of children to protect them against the evil eye and illness arising therefrom
   The inscription runs as follows:—"Protector! Protector! protect our little Ali from evil"
10. Horse charms, to protect horse and rider from illness and bad luck on the road. *Vide:* "EL BARAD." No. 1
11. ABU ABYAD } To protect children against the ill effects of the evil eye
12. GOZA }

2. El Alala (?), used in a similar manner or else as a fumigant of persons and places possessed not only by the evil eye but by any afrete (spirit) or gin.

3. El Gaine Magine (?), a Falatah root, powdered and mixed into a paste with other materials, after which it is moulded into a conical shape and dried, being carried loose in the pocket as a talisman; and, for a remedy, powdered and swallowed in small quantities.

Evil Spirits and Influences.

Evil spirits

Next to the evil eye, and an almost equally important factor in the causation of disease and disability, come a perfect army of evil spirits—genii, afrete, shatan, baahi, faries, ghosts, metamorphoses from man to animal and *vice versâ;* men possessed (Zarr, Shaukh), etc., all apparently under the very nominal control of Suliman, son of Daoud, their chief. There are besides an equal number of good spirits who do not concern us. The names of the evil spirits are legion, and can be found in the numerous Arabic writings on the mystic which form the text books of the Fiki.

To mention but a few well-known ones: Tiltamish, Yakoush, Habteet, Attatsh, Anshil, Bouni, Agbareet, Touni, Saroum, Karendees, etc., whilst (in Kordofan) of more local fame are El Howi, El Wadi, El Karar, Abu Gou, Abu Galha, El Ahmar, Kirsh El Fil, and Abu Seleba, of rather higher class and which apparently do not descend to the depths of evil and depravity to which other spirits of a lower rank fall. Amongst these latter there is a certain Um El Sibian, who accounts for greater harm, and who apparently provokes more preventive charms than any dozen others. She is described as a lean and loathsome old woman, possessing control over all mankind, travelling invisibly and destroying by her mere presence. She wastes children with disease, attacks pregnant women, and attends at child-birth, causing abortion, "animate retention," or still-birth. She renders men impotent and marriages sterile, she disseminates venereal disease, destroys crops at seeding and harvesting, and causes even monetary ventures to bear no fruit. The powers of this goddess of sterility and destruction are indeed far-reaching, and can only be combated by the use of one or more of the seven charms which Suliman extorted from her in the wilderness, and which are well known to the Fiki (*see* Figs. 63 and 64, and 67–73). Such charms are essential to the lover, the married, the pregnant, and especially to children, who, if unprotected, she delights to kill or deform with rickets, club-foot, curvature, rupture, etc., from which there can be no cure. Let this description of one serve as an example of many often equally grotesque and loathsome.

A famous evil spirit

Prevention and Cure.

Having considered under these two comprehensive headings "The Evil Eye" and "The Evil Spirit," the chief factors that always "by the will of God" account for the incidence of disease, matters of prevention and cure, already touched on in passing, require some further mention.

Written Charms. (Ketab, Hagab, Waraga.)

Written charms

Holy and mystic writings contained in neat rectangular or cylindrical cases of red leather, ornamented and suspended on a leather-carrying string, singly or in numbers. (Plate XLI.) These "words of power," either by their intimate connection in subject or name with an evil one (who seems thus to be deprived of much of his power), or by their purely religious bearing, or both, are extremely potent.

First in order of importance are the universal charms which, compiled according to loose formulæ, seem to possess unlimited scope and serve as prevention or cure for all the ills that flesh is heir to, and among all conditions of men. They are strange mixtures of religion and paganism, consisting as they do of quotations from the Koran, sometimes alone, but more generally coupled with other matter, frequently compiled on a system (El Abyada)

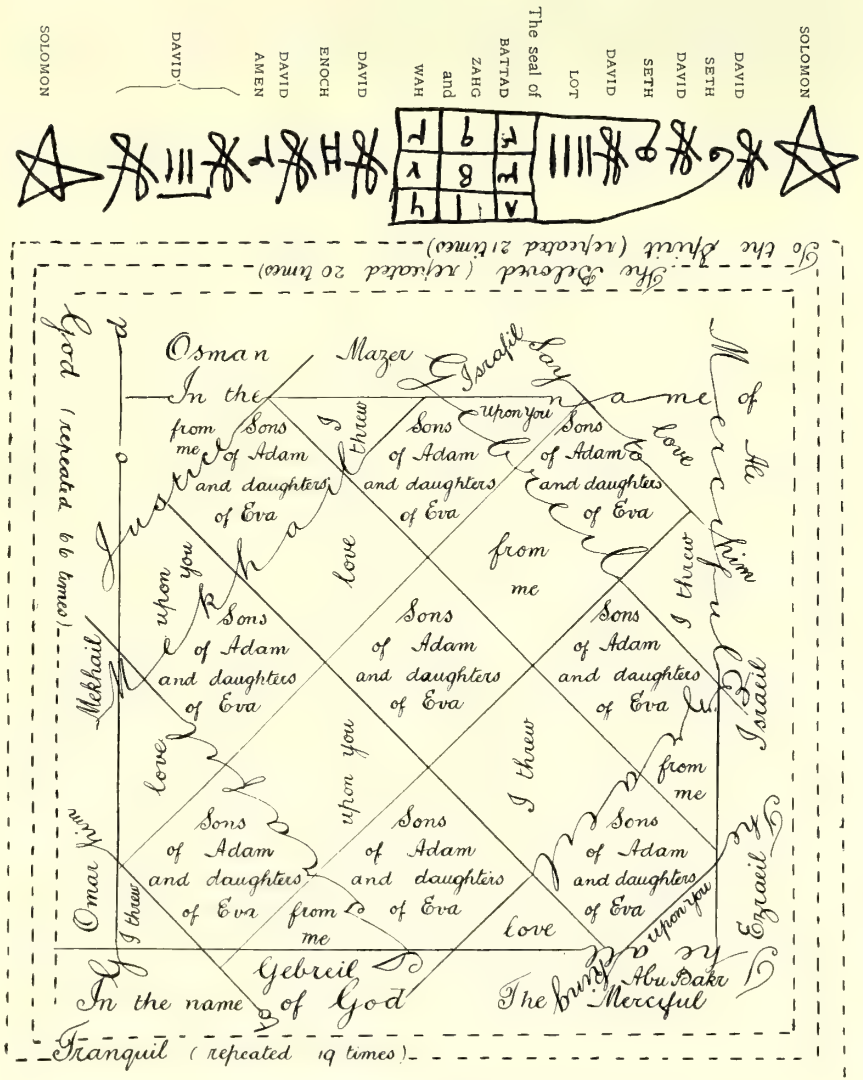


FIG. 61.—ENGLISH TRANSLATION OF "KETAB" (Fig. 62)

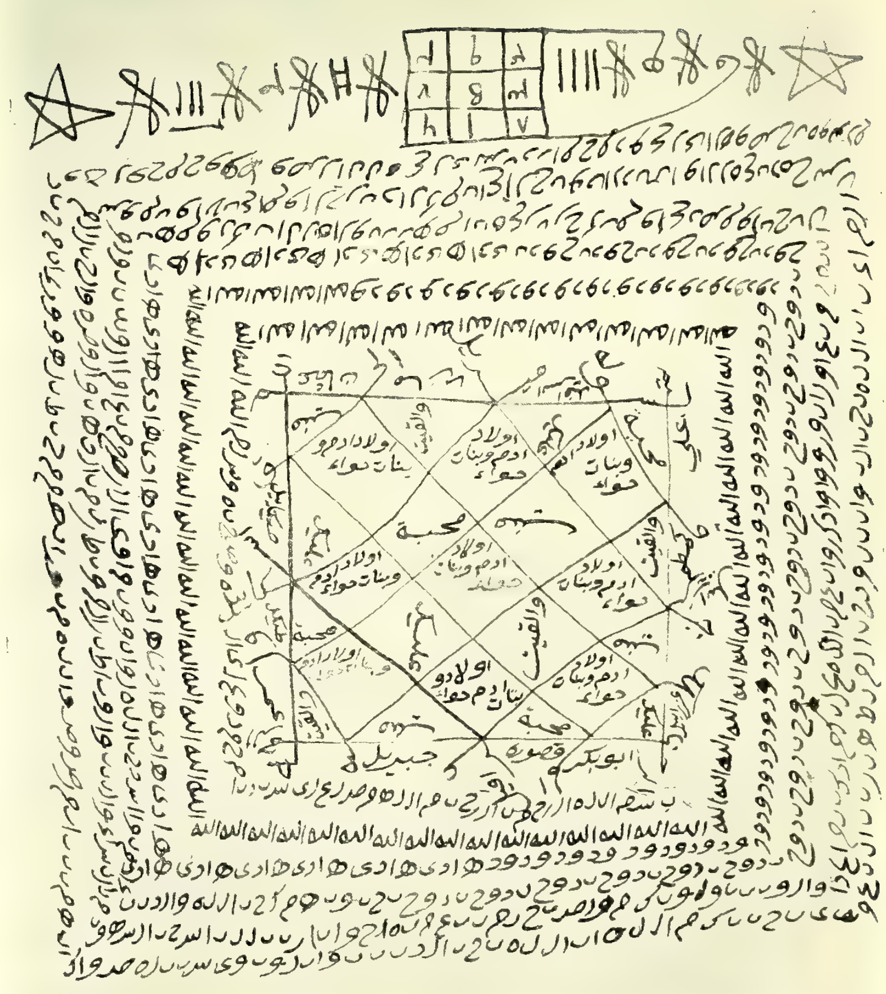
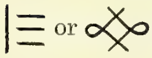
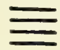


FIG. 62.—LOVE "KETAB" SHOWING THE CONSTRUCTION OF A "KHATIM"

peculiar to such writings, in which for greater mysticism letters and numbers are used, mostly of the ordinary type but possessing different significance.

A "Khatim" (seal) (Figs. 61 and 62) usually forms the nucleus for the charm; it consists of a sub-divided square (10–30 sub-divisions or more), each division containing a sign, letter, word, or pious ejaculation, or again numbers, letters and signs representing the name of a holy person, or simply a variety of "abracadabra" arrangement. Such nuclei are, again, surrounded, as a rule, by long repetitions of holy words and phrases (reading in corkscrew fashion from within outwards), the exact number of repetitions having an important bearing on the remedy aimed at—while distributed through the text, commonly at the beginning and end of passages, are various mysterious signs, such as:—

 Sign of Suliman (Solomon)  Sign of Adrise (Enoch)

 Signs of Daoud (David)  Sign of Loot (Lot)

 Sign of Sheet (Seth)

which must surely appeal to the illiterate eye.

The more mystic and less Koranic of these Ketabat can be produced by utterly ignorant Fikis who have but the slightest knowledge of reading and writing, sufficient to place on paper a few hackneyed words and expressions. Some do not even possess this rudimentary knowledge, and palm off on their credulous clients the most blatant forgeries composed of a series of scribbles resembling somewhat the genuine article, which they have taken as model. (Figs. 74–77.) One such impostor was, a short time ago, detected, tried and imprisoned at El Obeid, and a large number of his fraudulent wares confiscated.

Cost of charms

The cost, too, of these charms is outrageous. From the poorest the Fiki claims at least 10 to 50 piastres[1] a paper, while from the well-to-do sometimes many hundreds of piastres or their equivalent in kind, as also like extortions for prayers, ceremonies, sacrifices, etc.

The less pretentious but more scholarly Ketab consists simply of selected quotations from the Koran of verses and chapters recognised as having specific effect on specified complaints, etc., or even verses referring by word alone to the part (eye, ear, etc.) affected.

Use of the Koran in charms

Thus for protection against the attack of evil spirits there are certain verses from the chapter of "Genii" (71) and the chapter of "The Cow" (2) verses 55 and 254. Against the attack of enemies and the evil eye "The Chair," certain verses from the chapter of "The Cow"—which is held in the very highest esteem. Against all bodily disease the chapter of "The Unity" (112) which, together with the chapter of "The Cow," is looked upon as particularly holy and powerful in effecting good.

In diseases of the eye, "The Splitting Asunder" (84, verses 21 and 30). For headache chapter 93, verses 20 to 24.

At child-birth—"Abu Lahab" (111); "The Opening" (94) is another very favourite chapter, read aloud before the commencement of any treatment, and set on paper as a charm.

Ketabat may also be derived from the supplementary Holy Books and from the writings of holy men, amongst whom is numbered the Mahdi. The prayers and exhortations issued by him during his life are still copied and circulated in all good faith, a faith which is deemed to have no limitations to its power of cure, save those arising through the unholy living and fleshly weakness of the patient and practitioner.

[1] About two to ten shillings English money.

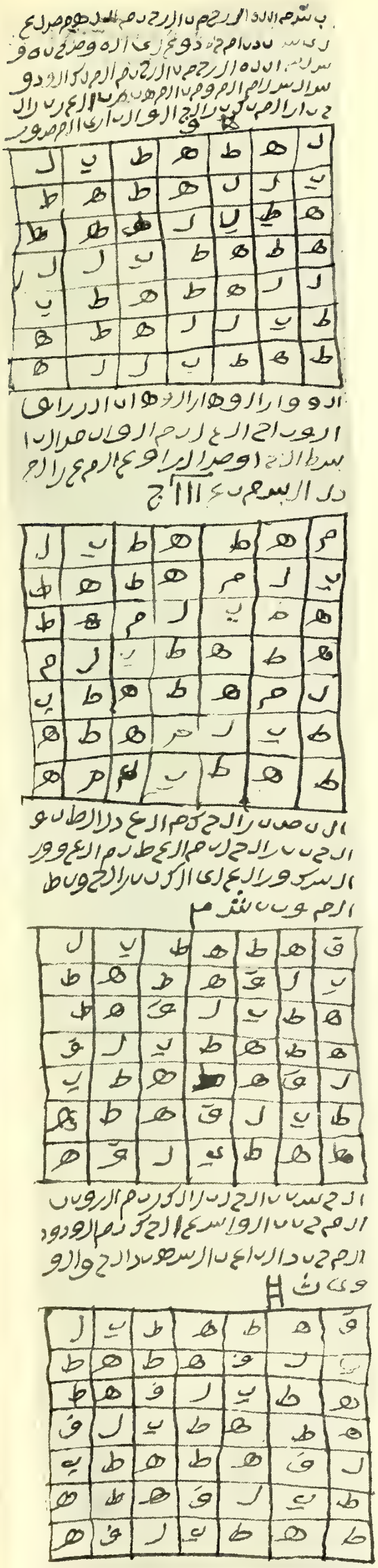


Fig. 64

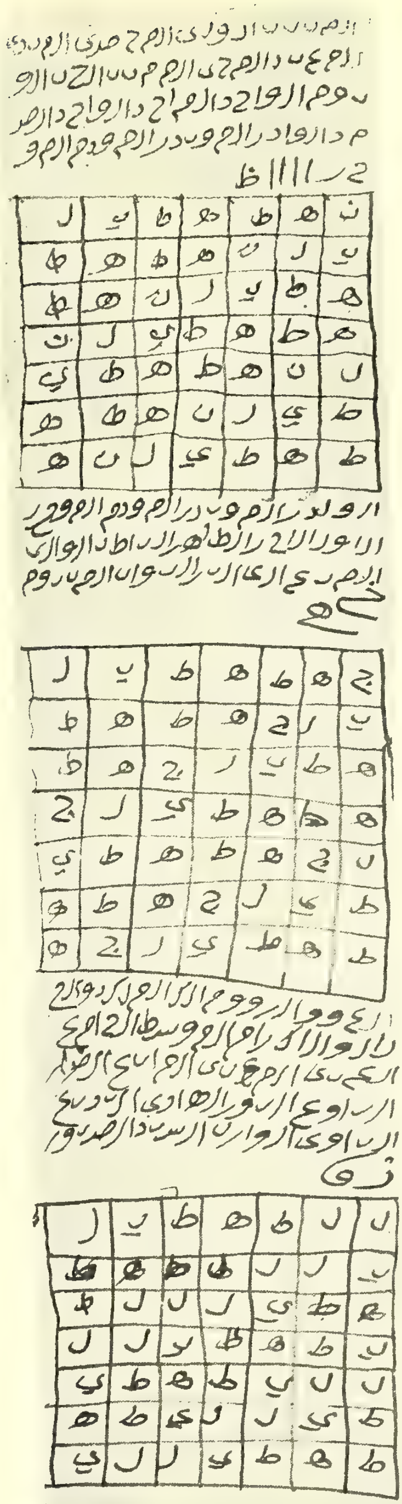


Fig. 63

Figs. 63 and 64. The seven charms against Um el Sibian. As protection during pregnancy, child-birth and infancy; and as a safeguard against sterility, insanity and evil spirits

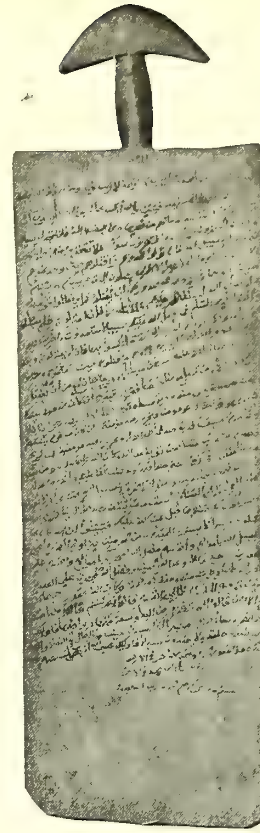


Fig. 65

Lohn (or writing board) on which Koranic phrases, mystic inscriptions, etc., are inscribed by Fikis (holy men). The ink when dry is washed off, and the resulting fluid prescribed as medicine for internal administration and external application in cases of illness, local or general. This course of holy writ in solution constitutes, and is termed El Mahaia

Fig. 66

Holy Water. Water from the Prophet's Holy well, Zamzen, at Mecca. Used in small quantities as a specific for all ills, and imported in metal flasks by pilgrims

Hence the more irreproachable the author the more potent his charm, and repeated failures redound against his credit; whilst some well-worn charms of saintly men gather power with years, and become as comprehensive in their effects as many of our quack remedies themselves.

Written charms can be compiled, therefore, against every conceivable form of disease and disorders of mind, body and soul, no matter what the cause, as well as for the gratification of every wish, good or bad, and as protection against every evil. There are many books written by the educated Fikis of Egypt and elsewhere giving, I believe, in detail, all particulars relative to the subject, and forming the ground-work on which the provincial holy man bases his procedure.

Other varieties of charms.

Various forms of charms

The roots of various trees and plants which possess supernatural powers against evil spirits, evil eyes, and the attacks of reptiles are worn simply suspended in a loop of leather, or in a small leather case, or packed into the hollowed extremity of a gazelle horn (then called Kadug, Plate XLII., fig. 7). They are often hung in company with written charms against the same evil, and act, not only as a protection, but in case of necessity as a remedy.

They are:—

1. *Galagil* (?). Against the sting of scorpions. When worn, a scorpion will not approach, and can be picked up and handled with impunity. As a cure the root is charred and used as a cautery, when it is supposed to "suck out the venom."

2. *Wad Elbrah* is another root possessing similar qualities—it is carried in company with a piece of *Ushar* bush root, to which it bears a male relation, the *Ushar* taking no active part in the cure.

3. *Kasir Aswil* (?). Against snake bite. Snakes dare not approach the possessor and on sight of the root they are said to rear up, hiss loudly, and then fall to the ground as though dead. For a remedy, it is charred, used as a cautery, and small fragments are also swallowed. In conjunction with this root is often carried a circular fragment of skin from the large lizard (*Warana*[1]), called locally *El Waral* or *El Zuhluf*, the rough surface of which is used to refresh the site of injury before cauterisation (Plate XLI., fig. 11).

Roots and plants

4. *Damin Ashara* (guarantee of 10).

5. *Damin Khamsa* (guarantee of 5). Have a similar use and action to 3.

6. *El Alala* (?). Against evil spirits, the evil eye and reptiles, being worn as a protection and used for remedy as a fumigant of persons and places; or applied in a spittle paste to the interior of the nostrils.

7. *Fiki bila Dowaya*—found in Central Kordofan.

8. *Salah Mawgood*—growing in the Gebel district of Southern Kordofan. Have the same properties as *El Alala*, but to a lesser degree.

9. *El Shari* (?). Against giddiness, the evil eye, and impotence; the root being powdered and used as snuff.

10. *El Gaine Magine* (?). Also against the evil eye.

11. *Abu Tamara*. The root of a variety of palm tree, a safeguard against impotence, and a general charm for success in love. Small quantities are eaten as an aphrodisiac and to fortify the owner in hardship and danger.

12. *Sharab El Shamsein.* (The drinker of the two Suns.) Also named *El Shams El Maroof.* (The favoured of the Sun.)

A tree so called because its branches and roots are said to always point towards the

[1] Probably *Varanus niloticus.*—A.B.

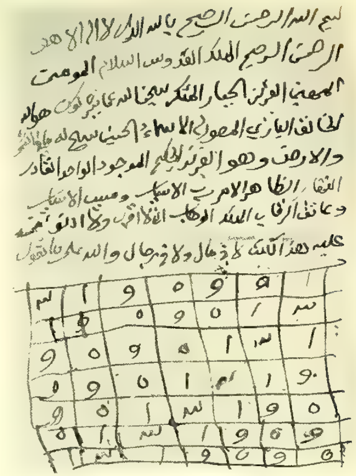


Fig. 67

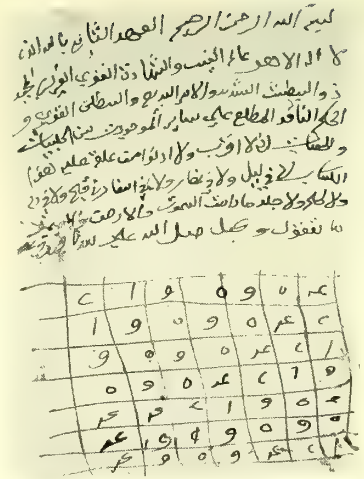


Fig. 68

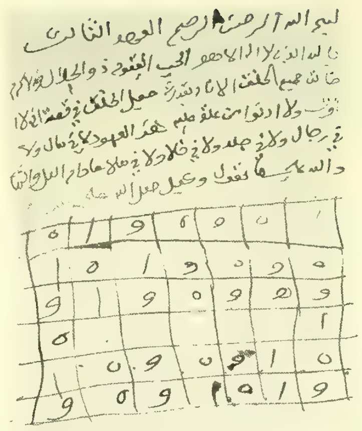


Fig. 69

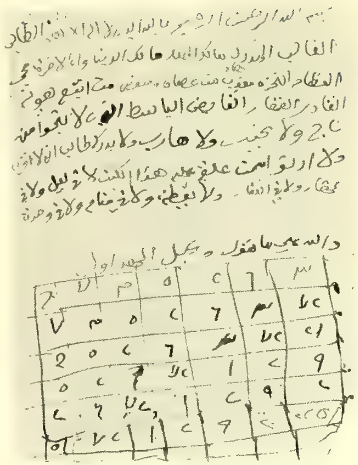


Fig. 70

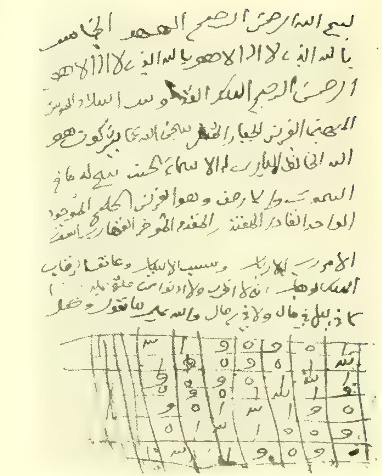


Fig. 71

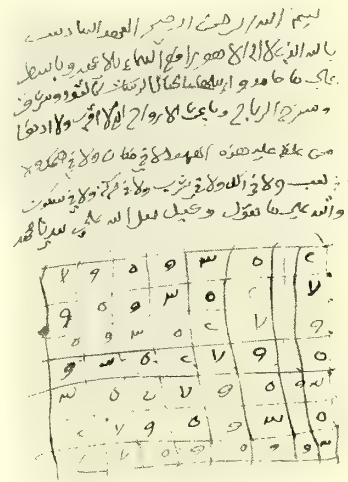


Fig. 72

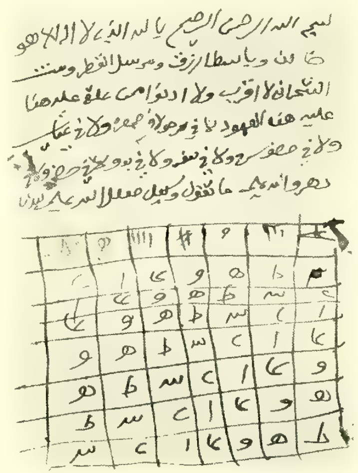


Fig. 73

Figs. 67 to 73
The seven written charms against the power of the evil fairy or witch Um el Sibian

rising and setting sun; it grows in Darfur. The bark and roots possess the same qualities as in the case of *Abu Tamara.*

Many of these will be referred to more fully under the heading of "Local Drugs."

There are besides other medicinal preparations prescribed by the learned, the composition of which remains quite unknown even to the possessor, the charm having not infrequently been handed down from father to son for many generations. I possess one such, over forty years of age, which was compiled by one of the Mahdi's physicians and presented to me by his son.

The childhood charms for protection against the evil eye: *Abu Abiad, El Goza,* and *El Hafiza,* have already been mentioned; the two first, carried in pairs, are, I suspect, constructed to resemble eyes, probably of similar origin to the Eyes of Horus and various other eye designs used for centuries past in like manner.

Stones.

Stones as charms

Certain rarer stones possess to the native idea curative properties, and hold, I imagine, the same colour, and hence superstitious, influence over the mind as they have done and do in all countries and at all ages. These are:—

1. *El Barad* (Plate XLII., fig. 1), an opalescent whitish stone, said to fall from the sky[1] with the hail, hence the name (hail storms being not uncommon during the *Kharif*). It is worn by the man to protect his horse against *Nigma* (horse-sickness).

2. *El Ferous* (turquoise), (Plate XLII., fig. 6). Is used in cases of urinary retention, as follows: A *Sibah El Yusur* (jet rosary) being secured round the patient's loins, the ferous is dropped into cold water, stirred several times, and the fluid drunk as medicine. This stone also brings good luck for the day if looked on by the wearer the first thing on getting up in the morning, its luck-giving properties being recognised in Africa apparently as well as in Europe.

3. *El Hagar et Dam,* or *Fas et Dam* (blood-stone) (Plate XLII., figs. 2 and 3)—an opaque red stone bearing the same popular name amongst ourselves. It is worn in a ring or round the neck, and is reputed to protect against sunstroke and headache; "a solution" made in boiling water being applied externally and administered internally as a cure in either condition. It also stops nose-bleeding when tied tightly round the temples.

4. *El Hagar el Akhdar* (Plate XLII., figs. 4 and 5), a hard green stone resembling spar, possessing the same styptic properties as the above.

5. *Hagar et Horra,* or *Ain et Horra* (cat's-eye), a polished, pure white stone, worn by men on the finger or wrist to safeguard the owner against having children by other women than his legitimate wives. The careful husband, too, before leaving an untrustworthy wife for any period, soaks this stone in sour milk, which he then gives the woman to drink; after which, should she commit adultery, there will result no illegitimate offspring.

The part played by special graves

6. Stones from the graves of the holy (Plate XLI., fig. 12). The small white stones which decorate the native burial grounds are procured from well-known and reverenced graves, and worn as a protection against evil and disease. They also bring good luck and sanctity. They are worn in small fragments carried in tin, leather, or horn cases. It is remarkable the reverence and awe in which these graves are held by the people, and the degree of fanatic and frenzied devotion exhibited by pilgrims visiting them. Various graves are famous for differing miraculous qualities, such as the healing of wounds, the restoration of health and sanity, the granting of a child to the childless. Some are used as places of safe deposit, for belongings discarded on the road—no thief presuming to rifle

[1] It is interesting to note that not more than a century ago a like origin was ascribed to the "worked flint" implements of primitive man distributed so plentifully over the surface of enlightened Europe.

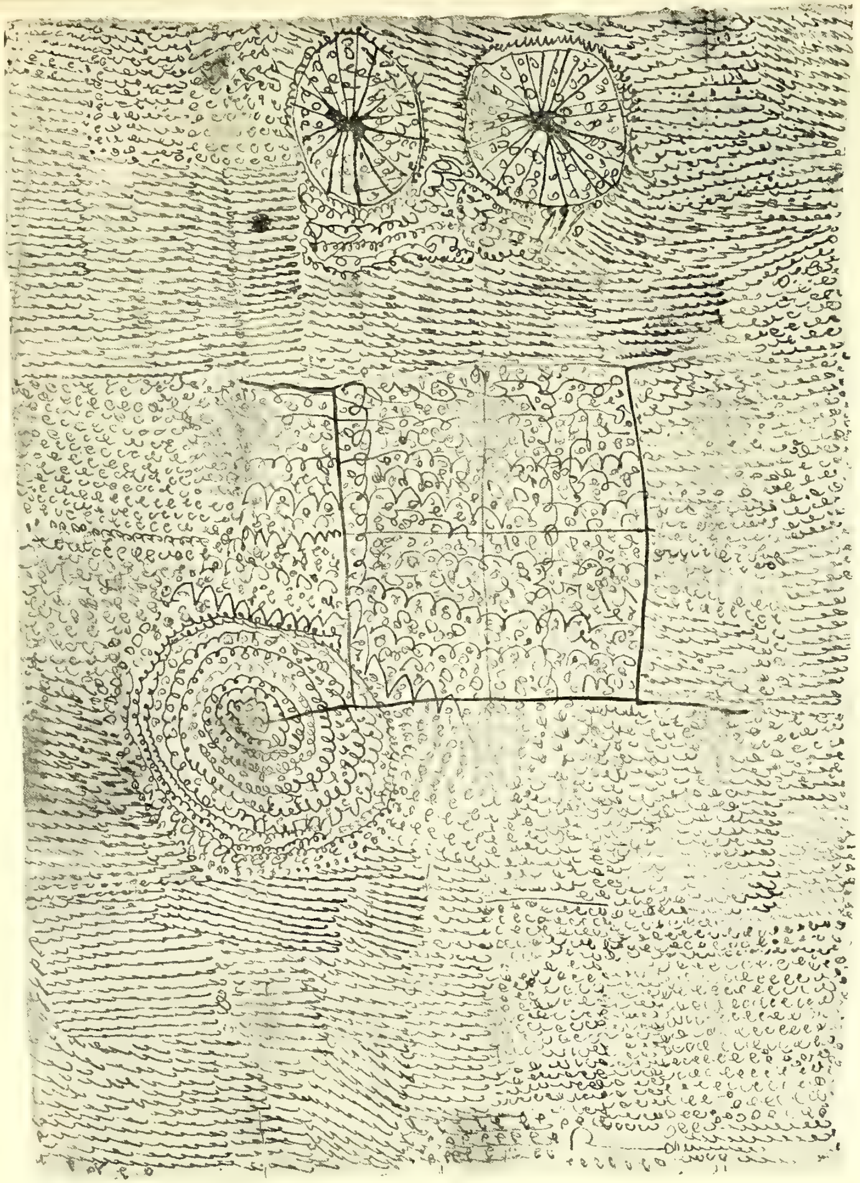


Fig. 74

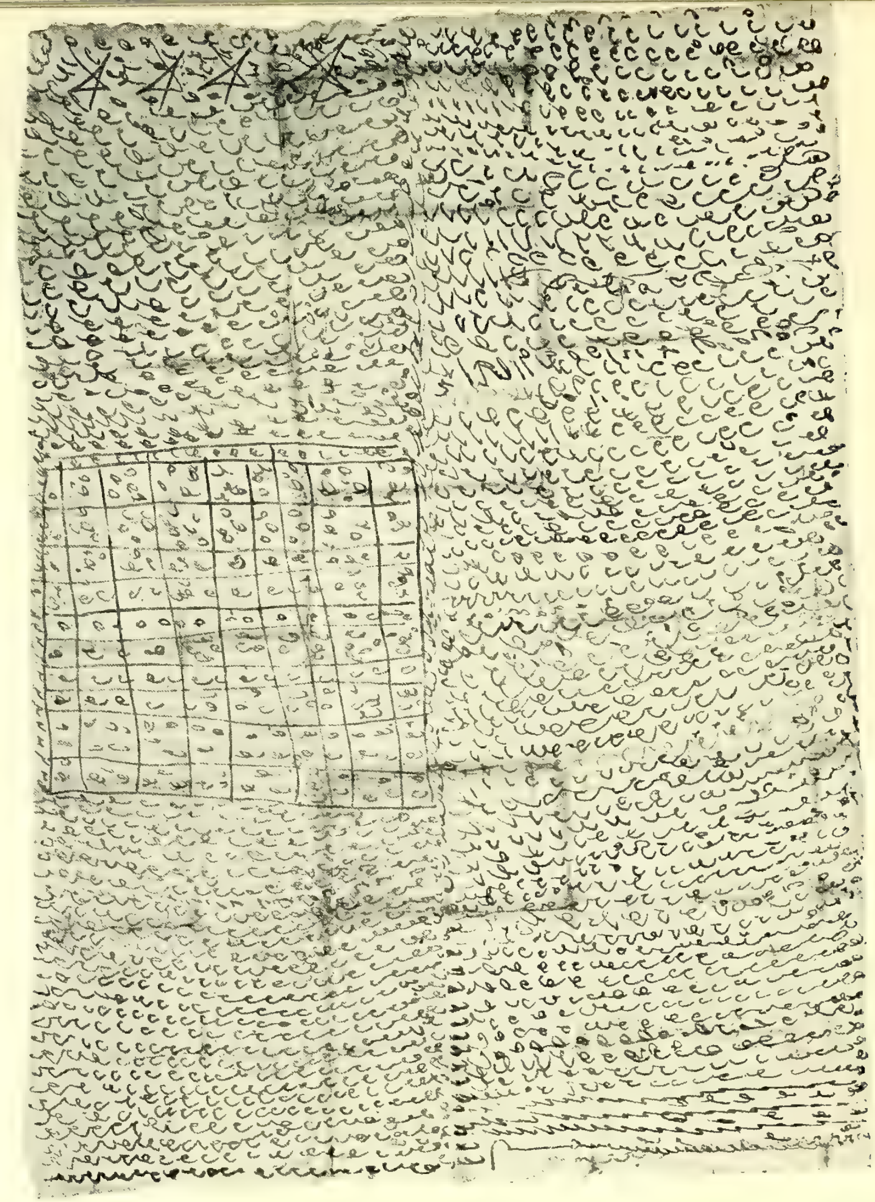


Fig. 75

Spurious charms compiled by an illiterate impostor, in imitation of the genuine article. This person, who, posing as a Fiki (holy man), for a considerable time sold his wares to the ignorant, was eventually detected and punished them—and all receive small offerings and decorations. They are the favourite spots, too, for the swearing of solemn oaths, and should such an oath prove false dread consequences are expected.

The greatest care is taken in the preservation and cleanliness of these graves, even in the most out-of-the-way places.

In the case of *El Barad* we have an instance of the master wearing a charm to protect his beast from disease. The beast may in like manner carry charms to safeguard his master from ills and dangers on the road (as well as others to heal and protect himself). (Plate XLII., fig. 10.)

Method of wearing charms

Mode of Wearing Charms. The position of a charm on the person differs according to sex, status, and the effect aimed at. Thus amongst women, who naturally carry larger numbers than men, they are suspended round the neck, hanging on a level with the breasts and hips, and having in these positions usually a bearing on love or its sequelæ. Men wear them fastened round either arm above the bend of the elbow, often in large bunches, which are considered highly ornamental (this is well shown in the illustrations of the gum collector, Figs. 205 and 208, *pages* 419 and 425); the Kordofan knife being carried in the same position, the sheath of which is usually supplied with two or more surgical instruments (*Samandia*), and often with emergency roots and writings of small size, against the evil eye, reptiles, etc. (Fig. 86.) Round the wrist too, or attached to the *Sibah* (rosary), are often smaller or more valuable Hegabat.

The better-class Arab wears his charms on his left flank, suspended in line on a single silk or leather cord passed over the right shoulder. They lie, as a rule, next the skin, and are here quite hidden by the clothing.

In localised disease, where special local effect is sought, the Ketab is fastened over or above the site to be acted upon; thus for wounds of extremities, strained joints, faranteet,[1] etc., it is tied round the injured limb immediately above the lesion, whilst for headache and toothache round the temples and in abdominal troubles round the waist; often for a single effect two or more Hegabat are required. So, for increasing sexual vigour, four are worn—two at the breasts and two at the hips, suspended or sewn into the clothes; for preventing conception there are three; and again three are required if one wishes to render a person sterile, two being secretly placed beneath the subject's angerib (bed) and another deposited at night within a neighbouring grave. In most severe or prolonged diseases, and during child-birth also, numerous Ketabat are hung round or attached to the bed, as well as on the person of the sufferer; whilst if a drug and writing bear on the same ill they are usually coupled one in front of the other on a single cord (Plate XLI., figs. 1 and 10). Amongst a certain class who cannot afford the true article, false charms holding only small blocks of wood instead of writings are worn (Plate XLI., fig. 15) as a sign of respectability or prosperity, and also with the view of hoodwinking not only seen but unseen neighbours; these are usually conspicuous by their weight and bulk. Strips of leather passed round the body or limbs and knotted, though unaccompanied by any writings, are also worn for protection, and correspond to the luck knots employed, I believe, by other primitive people.

Routine methods of supernatural cure

Having detailed these passive remedies, some of the more usual routine methods of supernatural cure require brief mention.

Prayer and laying on of hands

1. *Prayer* and *Laying on of Hands*, together with exhortations to the departed Fiki, saint, and sherif, as well as to the more mysterious "unseen," are offered up (for a wage) by the holy man on behalf of the sufferer before, during, and after courses of

[1] Guinea worm.—A.B.

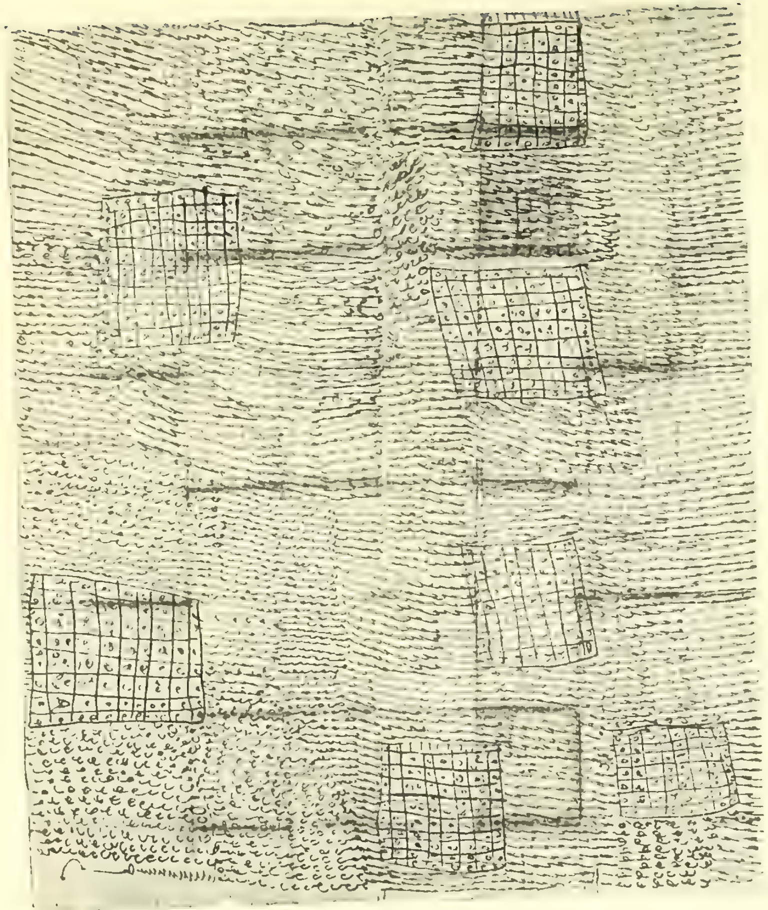


Fig. 76

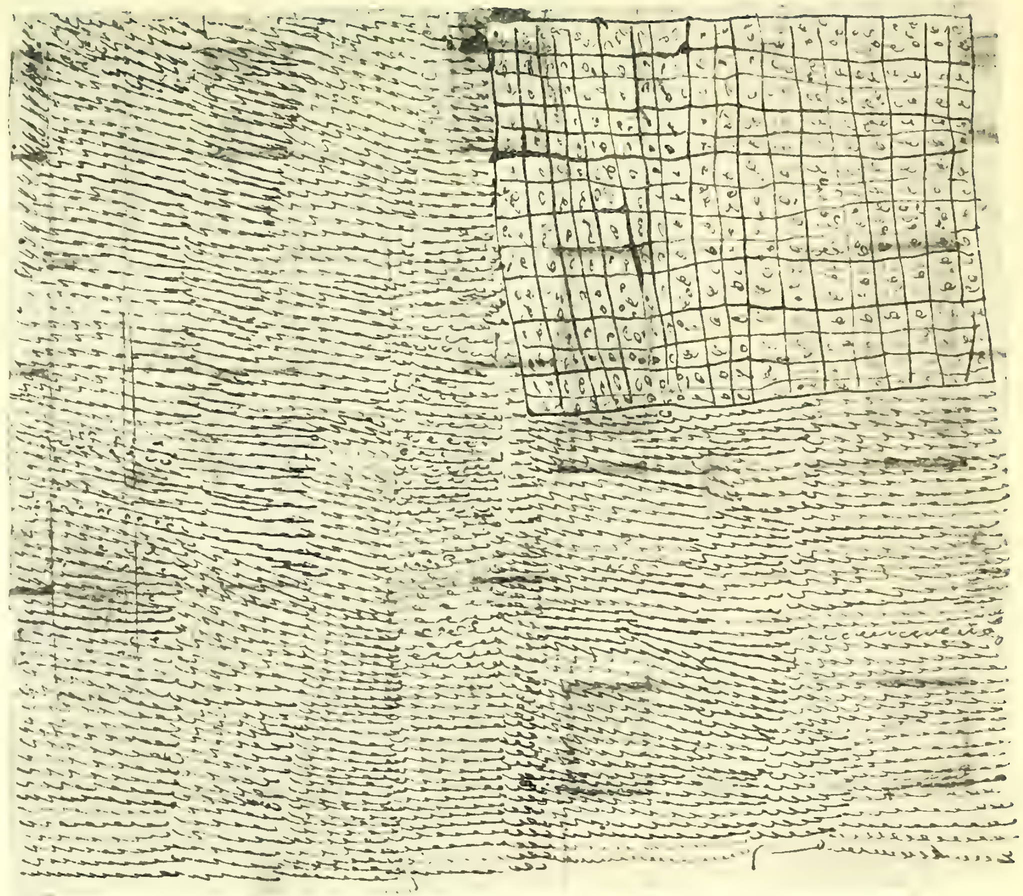


Fig. 77

Spurious charms compiled by an illiterate man posing as a Fiki treatment. It is seldom undertaken alone, however, as the sale of drugs and Ketabat, and the following more expensive and imposing methods, are generally recommended :—

The mystic writing

2. *The Mahaia,* to which I have referred elsewhere, consists of the internal administration and external application of a solution of the same holy and mystic words and signs found in the Ketabat, as also fumigation by the smoke given off by such when burnt. These writings are made on paper, raw hide, and various specific roots and drugs (*Garad, Alala,* etc.), in which case the medicinal element is presumed to play a part—which are then boiled in water and the resulting "dowa"[1] prescribed. The same effects (due, however, solely to the supernatural) are obtained by writing on paper, "Lohn" (writing board) (Fig. 65), stone, glass, or metal and simply washing the ink off the surface for use as medicine. During the preparation of a *Mahaia* there is often much prayer and ceremony.

The spitting cure

3. *The Azima (spitting cure).* Undertaken for any disease not obviously purely local, is, I believe, an almost universal custom throughout the East from time immemorial. The powers of cure rest chiefly with descendants of the Prophet and particularly holy men, though any human spit is supposed to have curative properties. The usual routine is for the operator to kneel over the outstretched patient and after silent prayer to read the "Fatah" aloud, after which, with pious ejaculation, he spits thrice over the prone body, finally saying "Amine" (Amen) and rising to his feet. The patient may show considerable signs of uneasiness during this procedure, and if it is so willed begins rapidly to recover.

Modifications of the treatment are :—

(a) Mixing the saliva with sand (as referred to in our Bible), for application usually to the nostrils, eyes, and forehead.

(b) Chewing up roots, etc. and converting them into a pulp in the spittle for application within the nostrils already recorded.

(c) The expectoration of a holy man mixed with water and carried to the bedridden as a remedy.

The fire cure

4. *The Fire Cure.* For certain distempers of mind and skin lesions the sufferer may be passed through the flame, being swung by his shoulders and heels three times slowly over a fire. This is a most interesting, but by no means universal, custom. The Sherif, when enraged, may expose himself to fire without injury, as may also Zarr or Shaukh (those possessed by the spirits of the evil) ; whilst certain holy writings are said to resist the ravishes of flame.

The casting out of devils

5. *The Casting out of Devils.* In such an undertaking, the services of a powerful, preferably a hereditary, Fiki are required (certain old women also are adepts in the method by less holy means). This Fiki, in the first place, writes a charm on paper, board or glass, and manufactures a *Mahaia* for the sufferer to drink and snuff into his nostrils. Next, he writes a charm on paper, which he burns, the smoke being inhaled by the possessed (through mouth and nose), who is then bound in ropes or chains and left in a starved and solitary condition within a closed and darkened tukl[2] or room. After the space of three or four days the devil, as a rule, becomes restless, shows signs of wishing to depart and cries out, "Ana marakt" ("I am coming forth"), on which the Fiki—who, if not present, is hurriedly sent for—offers prayers, and then asks the devil how he intends coming out, to which the latter answers, "By the nose, mouth and ears." (Should he mention the eyes as a mode of exit, he is deceiving and will require further severe measures.) If, however, all goes well, the Fiki calls upon him to come forth (at the same time laying

[1] Medicine.—A.B. [2] Native hut.—A.B.

on his hands), which he may do, causing much outcry and distortion on the part of the patient, who, as a rule, falls back in a stupor, waking later in his right mind and with no memory of what has happened. This procedure can be varied and supplemented by fumigations of the room and body, prayers, fastings, exhortations, etc., especially in the case of stubborn devils, some of whom, however, it is impossible to banish. The devil having been expelled a Ketab is at once written by the holy man and placed round the patient's neck to prevent his re-entry.

6. *Sand-gazing.* The Falatah, who form such a considerable factor in the populations of the large towns of the province and who are reputed to be a nation of Fikis, have recourse to sand-gazing, for the purpose of making a diagnosis and predicting the course, treatment and issue of an illness, the medium being a small boy (one who has never been bitten by a dog nor burnt in the fire). The latter, gazing on the word "Allah" in the centre of a Khatim traced in the sand, and under the controlling eye of a Fiki, calls to the "King of the Devils," who, on his arrival, will answer any questions put, regarding the sick, through the medium of the child, by this time sunk into a trance. (Water or a mirror may be placed for the boy to gaze into instead of the sand.) Sand-gazing

7. *Buried Fowl Cure.* In cases of mysterious illness and bad luck, these people (the Falatah) also adopt a strange prophetic and curative custom, as follows:— Buried fowl cure

The sufferer procures a cock and a sheep, the latter being sacrificed and the flesh given to the poor. The former is fed with a *Mahaia* preparation and has certain roots inscribed with Koranic quotations placed round its neck. It is then put under an inverted "burma," or basket, and buried below the ground. After a period of seven days (during which time the Fiki is supposed to pray vigorously) the bird is uncovered. If found dead, grave consequences are to be expected. If alive, all will be well; the Fiki is highly paid and the cock killed, its flesh being cooked and given as a specific to the person who has undertaken this somewhat expensive and decidedly cruel remedy.

From the foregoing pages it will be gathered how intimately superstition, in the form of magical beliefs (sympathetic, symbolic, etc.), faith in mystic writings, the influence of spirits, ghosts, and the like, and the belief in talismans, amulets and charms, has become blended with the religion of these inhabitants of Kordofan; and in consequence what an all important part it plays among their medical customs and practices. It is, indeed, one of many examples of the encroach of magic, fetishism, and debased worship into a purely monotheistic belief, and only shows what a little span separates these rugged people from their ancient idolatries, between which and so-called fetishism many imperceptible graduations without an appreciable difference exist. In viewing these beliefs, however, one must take into consideration the unstable nervous and mental condition of all primitive people, the influence on them of ignorance, suggestion, exaggeration, surrounding, etc., coupled with a strong animistic tendency, all of which help to impress a sincere faith in the supernatural scarcely credible to the more enlightened, although in fact the very faith (psychic concentration, mental suggestion) that is *the* potent factor in our so-called "Faith" and "Christian Science" cures, which is certainly not without the same influence amongst these people as amongst ourselves.

Local Drugs, etc.[1]

In collecting the following drugs (those of common use in Kordofan) it has been by no means easy to assign to each its specific uses, or even to discover such essential Local drugs

[1] For the botanical names of most of the plants mentioned, one is indebted to Mr. A. F. Broun's "Catalogue of the Flowering Plants of the Sudan."

Local drugs

facts as the variety, distribution, action, etc., of each. The "Hakim" and drug vendor seem often to know little beyond the native name or names of their wares, which are presented to the enquirer only as specimens, scraps of bark, roots, seeds, etc., beyond which obvious facts further information is difficult to obtain—on asking their use one is commonly met with the reply, "Alashan et Dam" or "Dam sakit," the word "Dam" (blood) embracing every conceivable form of illness, and often only on patient questioning can more explicit details be elicited, and a consensus of opinion obtained.

1. *Kohl.* (Black Antimony.) Sold raw in the *Sûk.* It is powdered and used for cosmetic purposes, being painted round the margin of the eyes and introduced into tribal scars and tattoo punctures to produce a permanent blue coloration. It is also applied to granular lids, alone or mixed with powdered sugar.
2. *Zabid Malih.* Bone obtained from the cuttle-fish, imported from Egypt. Powdered and mixed with Kohl for use in cases of granular lid and conjunctivitis.
3. *Succar Nehat.* Sugar extracted from honey. Eaten as a sweet. Also used to "clean the stomach" in indigestion and again powdered with Kohl for application to granular lids as a caustic.

   Powders are applied to the eyes on a small probe or brush, which is passed along the margins of the lids and surplus powder left among the eye-lashes.
4. *Sheeh.* Dried leaves of the sheeh tree (?), used as a powder or decoction in cases of flatulence and gonorrhœa. The drug is imported from Egypt.
5. *Hargal.* (*Solemnostemma Argel,* Hayne.) The leaves of a shrub used alone or with sheeh in dyspepsia and flatulence and as a specific in fevers. Imported from Egypt, also grown in the province. Purgative action.
6. *Ardeb* fruit. (*Tamarindus indicus,* Linn.) The fruit of the tamarind tree. A thick paste is made by boiling the fruit until most of the water has evaporated. This paste is then rolled into balls and dried in the sun. For use these balls are dissolved in water, the solution being drunk as a purge (senna leaves being often added) and as a febrifuge. (By far the most popular specific for fever in Kordofan, where the tree flourishes and is widely distributed.)

   Ardeb bark—used as a tonic and febrifuge. The root as a specific in chest complaints.
7. *Shab.* Alum (imported), powdered or dissolved, and used for application to wounds and in cases of conjunctivitis. Also applied to the gum in toothache and given internally in gonorrhœa and leprosy.

   Burnt with charcoal, to fumigate children suffering from fever.
8. *Garad.* Fruit of the Sunt tree (*Acacia arabica*), a universal remedy. The fresh fruit sucked in cases of "Chest trouble." An infusion drunk as a specific in fevers, syphilis, gonorrhœa, leprosy, and many other diseases.
9. *Henna.* The leaves of the Henna shrub (*Lawsonia alba,* Linn.), powdered and added to water or vinegar, are applied to the body surface in cases of fever, especially among children. It is also painted over sites of inflammation and used for cosmetic purposes to the finger and toe nails, the palms of the hands and soles of the feet.
10. *Rashad.* Aromatic seed (?). Imported from Egypt. Powdered and boiled with water it is used as a stomachic in indigestion, loss of appetite, etc.
11. *Ishba.* (*Sarsaparilla*) (*smilax*) sp. (?) Imported. Used in decoction for syphilis.
12. *Helba.* (*Trigonella occulta,* Del.) The seeds cooked and eaten in disorders of the stomach and in cases of rheumatism.
13. *Kammud*—Aromatic seeds. (? .) Powdered and used as snuff in cases of headache. A decoction given to relieve colic. Imported.
14. *Mahlab.* (? .) A decoction of the seeds used in cases of colic, especially among children.

Local drugs

15. *Garingan.* (? .) Dried root bulb, powdered with cinnamon bark, and a decoction made for use as a stimulant.

16. *Cinnamon*—used as a stomachic, aromatic and fumigant.

17. *Natron* or *Jardak.* Common "surface salt," picked up in dry, hard yellow cakes in certain districts of N.E. Kordofan, and composed chiefly of chlorides and nitrates. It is largely used for medicinal purposes in all stomach and intestinal troubles. For food and cooking; given also to horses and cattle to improve their condition. Powdered and used as a surgical dressing.

18. *Samn* or *Semna.* (Native Butter.) Largely used medicinally, as a medium for other drugs. For local application and for internal administration in various diseases, as much as a pint being drunk at a sitting and often over prolonged periods.

19. *Karkade.* (*Hibiscus sabdariffa,* Linn.) (Red Sorrel.) The calyces used to brew "Sudanese Tea," a tonic and refreshing drink. This decoction forms a basis for many other drugs.

20. *Senna.* (*Cassia obovata,* Collad, and *C. acutifolia,* Linn.) The leaves used as a purge. Also dried and powdered as an application to burns and wounds. The seeds are sometimes added to marissa to increase its strength and flavour.

21. *Ushar bush.* (*Calotropis procera,* Ait.) (Sodom Apple.) The leaves are used in the brewing of marissa, the prepared corn being spread on a bed of these and allowed to ferment. Some of the white juice is also occasionally added to the marissa itself to strengthen it.

The bark, root, leaves, flowers, and seeds are all used for medicinal purposes, chiefly as strong diuretics and purges.

A variety of sugar is obtained from the flower centre (Kersi-El-Nebi), which is highly valued.

The white sap is looked upon as a strong poison, and if splashed into the eye the native considers blindness is sure to result; it certainly excites a violent conjunctivitis in animals (camels and horses), though I have never seen its effects on man.[1] It is used for local application in ringworm.

22. *Sakaran.* (*Datura stramonium,* Linn.) Distributed widely round El Obeid. The seeds are added to marissa to increase its narcotic effects, occasionally with fatal results. I believe it is a popular poison also.[2]

23. *Damin Ashara.* (? .) "A guarantee of 10." This root, which is very difficult to obtain, is carried by a great many Arabs and Nubas suspended round the neck or elbow, or attached to the sheath of a knife. It protects the wearer from bites of snakes. Should another be bitten, the end of the wood is charred and used to cauterise the site of injury. Small pieces are also eaten to hasten the cure. The natives have the greatest faith in the root. I have never seen it put to the test. Another root exists which protects the owner in like manner from scorpion bites.

(*a*) (*Damin Khamsa.*) (? .) "A guarantee of 5." Similar to above but not so powerful, as indicated by its name.

24. *Shagaret en nar.*[3] (Fire tree.) (? .) The root is dried, reduced to a powder and applied as a dressing to syphilitic ulcerations, leprosy lesions, and septic sores. As also the leaves of *Likbalie, Shatta* and *Gulum.*

25. *El Shairi.* (? .) The root of a tree, which is worn as a charm against the evil eye, the wearer being immune. When a person is attacked by the evil eye the root is powdered and snuffed into the sufferer's nostrils—much to his relief. It protects also against giddiness and sexual impotence.

[1] In India it is used to poison female infants.—A.B.

[2] In Egypt, but apparently not in the Sudan.—A.B.

[3] Probably a species of *Euphorbia.*—A.B.

Local drugs

26. *El Alala.* (? .) Considered and named the "King of roots." A guard against all evil spirits, who cannot remain where its smoke is. To disinfect a haunted room or the like a small piece is burnt. To rid a man of "devils" he is fumigated, with accompanying prayer, or else the Hakim, but preferably the Fiki, chews up a small piece of root and inserts the resulting pulp into the sufferer's nostrils. The root is worn also as a protective charm against sunstroke and snake bite in case of necessity, being used in like manner to *Damin Ashara.*

27. *Rabah.* (*Trianthema pentandra,* Linn.) Powdered root given in gonorrhœa, 2 drs. daily in water or milk. It produces vomiting and diarrhœa (often with blood in the stools) and acute nephritis; apparently a most dangerous drug. (*See* "Gonorrhœa.")

28. *Shourour.* The ash of burnt wood and grass used as table salt by Arabs and Nubas. Also employed medicinally as a purge and for dressing wounds.

29. *Anti-syphilitic Earth* (Tureba[1]). Employed as a drug in the cure of syphilis, brought from the neighbourhood of Bara, where it is found in limited quantities and sold in the *Sûk* at El Obeid. A decoction is made by shaking up the earth with water and drinking the product, one coffee-cup full morning and evening. It purges strongly and sometimes causes vomiting. The most potent quality, termed *Tureba Zokhri,* is obtained from Malimma, a place on the Nile near Atbara. It costs about 5 milliềmes ($\frac{1}{2}d.$) an ounce.

30. *Pills for Syphilis.* Full ingredients not known but made up with a basis of anti-syphilitic earth. (Their manufacture in pill form is of interest.)

31. *Hanzal* or *Handal.* (Colocynth, *Citrullus colocynthidis,* Schrad.) Used for the treatment of gonorrhœa and also as a purgative. Gotran tar is obtained from its seeds and is largely used for medicinal application to inflamed or injured surfaces, and as a dressing for wounds and sores in men and beasts.

32. *Gadda.* (Asafœtida.) Imported and used in stomach disorders, also in cases of guinea worm, gonorrhœa, and locally applied for the relief of toothache.

33. *Daiu.* (? .) Used in the treatment of syphilis.

34. *Tamra*—Tamr-El-Abid. (*Grewia villosa,* Willd.) The stem and roots of a shrub used in decoction for the treatment of syphilis and smallpox.

35. *Deina bana.* (? .) Small plant, used in decoction (leaves and stem) in the treatment of syphilis.

36. *Kadada.* (*Dichrostachys nutans,* Benth.) The root used in decoction for the treatment of syphilis.

37. *Simsim.* (Sesame, *Sesamum indicum,* D.C.) An oil extracted from the seeds used as a purge, also as an unguent and specific in many disorders.

38. *Hurua.* (*Ricinus communis,* Castor oil plant.) Oil extracted from the seeds used as a purge and as an application. The leaves crushed with water used as a poultice, as also *Bamia* and *Tundub.* The plant grows in many parts of Kordofan.

39. *Galagil.* (? .) The root of a tree carried as a preventive charm against scorpions. Whilst this is worn, scorpions will not approach and can be handled with impunity. For a remedy in cases of sting the root is charred and applied as a cautery—small fragments being swallowed in severe cases.

40. *Kasiraswil.* (? .) A root used as a charm against snakes and as a cure for their bites. A snake will not attack a person so protected, and when shown the root it is said to hiss loudly and sink in a torpid condition to the ground. It is used as a cautery "to withdraw the venom," and also given internally. The skin of the large lizard, called Warrel or Zuhluf,[2] is commonly used in conjunction with this root to refresh the site of injury before applying the cautery (Plate XLI., fig. 11).

41. *Abu Tamr Ahmar.* (? .) The root of a variety of date tree. Reduced to a

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[1] *Vide* Second Report, 1906, p. 237.

[2] Probably *Varanus niloticus.*—A.B.

pulp and packed in small leather charms, or in the cut ends of gazelle horns, it strengthens the nerve and body and renders the wearer fearless and brave in fight. Local drugs

42. *Balana.* (? .) Used by the Falatah Fikis in cases of sunstroke, fits, etc. A decoction of the root is bathed over the head and body of the sufferer.

43. *Ligna* (Falatah name); *Kulkul* (Arabic); (*Bauhinia rufescens*, Lam.). A root used by the Falatah in cases of leprosy—cut into small pieces, each of which is inscribed with words from the Koran—it is then boiled and the decoction given internally (*El Mahaia*).

44. *Boware.* (? .) A Falatah root, a decoction of which is drunk by one who wishes to communicate more fully with the spirit world, and used to assist the metamorphosis of man to animal (notably to the hyena): probably a narcotic.

45. *Um Raishat.* Dried muscle tissue taken from the left shoulder and upper arm of the porcupine (Um Raishat). It is administered in cases of difficult labour in the form of powder, which is mixed with water and swallowed.

46. *Wad-Elbarah.* (? .) (Thechild of yesterday.) A root obtained in the vicinity of El Obeid, and carried in conjunction with an equally-sized piece of the Ushar bush root. This latter, though having no active effect in the cure, exerts a passive influence on the Wad-Elbarah—to which it bears a feminine relationship. The two are carried together as a protection against snakes and scorpions. In case of poisoning by such, the Elbarah root is chewed into a pulp and this applied vigorously to the lesion.

47. *Fiki Bila Dowaya.* (? .) (The Holy Man without an inkstand.) The root of a small shrub growing in the vicinity of El Obeid. It is used as a protection against evil spirits and the evil eye, and as a cure for ills arising from the attacks of such. It may be employed as a fumigant, or chewed to a paste and applied to the interior of the patient's nostrils.

    (*a*) *Salah Mawgood.* (? .) A root derived from South Kordofan, which has a similar action to the above, as also:

    (*b*) *El Gainie Magine.* (? .) A root derived from the Falatah country (W. Africa). (*See also* 25 *and* 26.)

48. *Khara Hadid.* Refuse "slag" iron taken from the smelting furnace, used in decoction with various other drugs as a cure for syphilis, and as a general tonic.

49. *Habt-El-Muluk.* (The Seed of Kings.) Croton oil seed. Used as a drastic purge, from two to four seeds being taken at a time. The outer covering (which is considered poisonous) is removed, and the seeds when crushed are swallowed with milk or water.

The following drugs are imported from Egypt and elsewhere for use in Kordofan:—

50. *Zinzabil.* (Ginger.) From Egypt—used as a decoction in cases of fainting, acid eructation, and as a general tonic.

51. *Um Ushush.* The crushed leaves of the Helba (12)—used in decoction, in cases of indigestion, also as a fumigant.

52. *Kurkum.* (Curcuma.) A yellow root. A decoction is used in cases of indigestion and as a cosmetic dye to the face.

53. *Toom*, or *atoom.* (Garlic.) Imported, also grown locally. Used as a stomachic and as a cure for chest complaints. The common onion, Basl, is also largely employed as a specific in eruptive fevers, gonorrhœa, etc. The juice is applied locally to skin lesions.

54. *Shou.* Grown in and imported from Abyssinia. Powdered and drunk with sour milk as a vermifuge. [This is Kousso, the female inflorescence of *Hagenia abyssinica.* It is often called "*Shou habashi.*"—A.B.]

55. *Girft dud.* (Worm bark.) The bark of a tree (?), powdered and used as a vermifuge.

56. *Um Gheleila.* (? .) A small yellow aromatic seed used in cases of general malaise as a decoction.

Local drugs

57. *Kunush.* (? .) A root imported from Persia and used as a specific in syphilis.
58. *Simbil.* (? .) Leaves and branches of a small shrub rolled into bundles. The decoction is used as a cooling lotion in cases of fever and local inflammation.
59. *Tambac.* (Tobacco.) Grown in the Gebel district and introduced from Khartoum. It is sold in large circular cakes; a decoction being employed for use as a lotion in cases of local swellings and inflammations.

    (*a*) *Haza.* (? .) The flower and stem of a small plant, a decoction of which is given in cases of flatulence and dyspepsia.
60. *Habt-el-ain.* (? .) A black heart-shaped seed with a bright yellow centre. A decoction is made from the crushed seeds and used as an eye-lotion.
61. *Usfur.* (? .) A bright yellow minute flower used as a face dye, and the decoction as a cooling lotion locally applied in cases of inflammation.
62. *Kusbara.* (? .) A brown aromatic seed, used in stomach complaints mixed with the food or in decoction.

The following are imported for use as scent, incense, and for fumigation of the body:—

63. *Bahour.* (Frankincense.)
64. *Laban.* Resinous balls containing Bahour and other ingredients.
65. *Myrrha.* (Myrrh.)
66. *Sandalia.* (Sandal wood.) Used for incense and fumigation (*see also* 63, 64, *and* 65). Two qualities of oil are also obtained from this wood, and an alcoholic perfume extracted, all of which are much used and valued in the manufacture of "Dilka" for massage. It is apparently unrecognised as a remedy for gonorrhœa.
67. *Wad Abiad.* (? .) Burnt for fumigation; a perfume is also extracted and divisions of the stem are carried by children as a protection against the evil eye.
68. *Dofr.* The dried cartilaginous remains of shell-fish used for fumigation in fever and wasting disease.

The following are used in the manufacture of "Dilka" (ointment) for medical and general massage:—

69. *Zet-el-Nam. (Ostrich Fat.)* Very highly prized for local application in cases of sprain and injury, rheumatic arthritis, etc.
70. *Surratia.* A crude oil of cloves sold in two qualities, the better derived from Jeddah, the inferior from Cairo.
71. *Zet Sandalia.* A crude sandal oil sold in two qualities.
72. *Baida.* An oily unpleasant perfume extracted from the Mahlab (14).
73. *Magmoa.* A "pot-pourri" scent in which clove and sandal oil predominate.

The following are administered as aphrodisiacs:—

74. *Abu Tamara.* (? .) The root of a variety of palm.
75. *Shams-el-Maroof.* (? .) Root of a tree growing in Darfur.
76. *Khartite.* (Rhinoceros horn.)

The following drugs require brief mention to complete the list. They are dealt with more fully under subsequent headings:—

Murdu, or *Gulum* (*Capparis tementosa*). The succulent stem of this plant is dried, powdered, and used as a local dressing for septic wounds (as also *lime* locally obtained from the village of Kursi, *kursan*, *ghrur*, *shagaret-en-nar*, *likbalie*, and *shatta*), or in decoction as a specific for fevers. *Buda* root (*Strigia hermonthica*), *Talh-el-hamra* bark (*Acacia seyal*), *Habil* root (*Combretum multispicatum*) and Likbalie (?) are all employed in the cure of leprosy, the two first used in decoction, the latter two as fumigants. *Kalto* (*Ximenia americana*), *Kharasami* (called worm seed), and *Bamia* (*Hibiscus esculentus*) are specifics in the cure of gonorrhœa, whilst *Tureiha* (*Pterocarpus lucens*), *Kursan*

(*Boscia senegalensis*), *Ghrur* (?), *Tibet* (?), *Tiebra* (?) and *Denobia* (?) are used in the various courses prescribed for syphilis. *Shatta* (red pepper) is largely taken as a stomachic and also employed in poultice applications, for which purpose, too, *Bamia*, *Tundub* (*Capparis aphylla*), and Castor Oil leaves are used. *Samuk* (gum arabic) is prescribed in chest troubles and many other ills; it also forms a vehicle for various active drugs, the more usual vehicles being, however, milk, marissa, oil, butter and water.

Additional Drugs

Since Captain Anderson has been at such pains to give a full list of drugs employed in Kordofan, many of which are in general use throughout the Sudan, I think it would be a pity not to record the names of others which have come under notice. Most of them are represented in the Laboratories' museum, and from time to time, Mr. Broun, Director of Woods and Forests, has been good enough to aid me in their recognition. Amongst the organic group one may mention, jalap, aloes, gall-nuts, cannabis indica, hyoscyamus, fennel, cardamoms and cinnamon. All these have their place in the British Pharmacopœia. Others of local repute, but not honoured in like fashion, are represented by the Tebeldi fruit, the resin of *Gardenia thunbergia, dalle, balanites* and *albizzia.* Note by Dr. Balfour

Taking these in detail, we note that jalap, as a rule, comes from Mexico; but what look very like ipomœa seeds (*Mulkat*) can be bought as a purgative in the market at Omdurman. They are probably imported.

Aloe barbadensis is a native of Northern Africa. Gall-nuts are called *Afus* and probably come from Syria. *Sakaran* is obtained from *Hyoscyamus muticus* and *Datura fastuosa* as well as from *D. stramonium. H. muticus* is very rich in hyoscyamine and is used as a narcotic and poison. Egyptians make anodyne plasters from the seeds. Cannabis indica, in the form of *Haschisch,* is a forbidden luxury, but is to be found in the markets for all that. Opium is also often smuggled into Khartoum. Fennel is known as *Schumar,* and is used as a carminative. So is cinnamon, *Kurfit-el-dam,* a remedy of repute in so-called blood-sickness. Myrrh, mentioned by Captain Anderson, and, in Khartoum, termed *Murr Higazi,* besides its ordinary uses, is esteemed as a dressing for ulcers. *Tebeldi,* or *gongoleise,* is the huge fruit of the Baobab tree, *Adansonia digitata,* or "cream of tartar tree," which is very plentiful round about Roseires on the Blue Nile, and constitutes a wonderful feature in the landscape. The pulp of the seeds has a pleasant taste, due to tartaric acid, and is freely used as a diaphoretic, while it is also employed in dysentery. *Samk-abu-Baka*—the resin of *Gardenia thunbergia*—is to be found in every drug-dealer's basket and is valued as a purgative. *Trianthema salsoloides,* called *Dalle,* is said to be good for infectious fevers, probably on account of its disgusting odour. *Lalob,* the fruit of *Balanites ægyptica,* is another common purgative and is also said to be of value in the dressing of wounds. *Arad,* the pods of *Albizzia amara,* are often seen. The plant must be esteemed, as I am credibly informed it serves the purposes of an emetic and astringent, is good for cough and malaria, and can be utilised as a poison.

In the Bahr-El-Ghazal a root called *Kassa,* in the Golo tongue, is employed by the natives in cases of blackwater fever, while *Tili,* a powdered red wood, possibly from *Terminalia splendida,* has a reputation in dysentery. *Butyrospermum parkii* (butter tree) is used both as a food and as a medicine.

Amongst the inorganics, sulphate of copper and salts of iron and zinc are found, but these do not play so important a part as the vegetable remedies. *Gardugga,* a favourite purge, consists of common salt and the sulphate and the carbonate of soda.—A.B.

Fever

Drugs used :—

Treatment of fever

1. *Ardeb.* (*Tamarindus indicus.*) Infusions of the bark, root and fruit *(Tamir Hindi)* of the Ardeb is probably the most useful and universal treatment for fever in Kordofan, where the tree is widely distributed.

   The fruit is boiled and reduced to a paste, after which it is dried in cakes and sold as a drug, being a popular tonic and remedy for many ills.
2. *Garad* (fruit of the Sunt tree). (*Acacia arabica.*) A decoction of this fruit is largely used in fever. It has an astringent action.
3. *Hargal.* (*Solemnostemma Argel*). Half an ounce powdered and drunk in water every morning.
4. *Murdu* or *Gulum.* (*Capparis tementosa,* Lam.) Used in decoction. It is poisonous in large doses.
5. *Taysin.* (? .) The root used in decoction.

Local treatment :—

1. *Massage* with dilka, or common oil; simsim, or semn, is employed in severe cases, the patient being told to avoid the sun and cover himself well, especially as to the head and face.
2. *Blood letting* (the universal remedy) is also resorted to as a preventive (before the rains), as well as a remedy, the site chosen being the back of the neck.
3. *Fumigation*—with smoke of red pepper, alum, dofr, etc.

Treatment of splenomegaly

4. *For Enlarged Spleen.* A mixture of powdered iron ore and *Shatta* (red pepper, *Capsicum frutescens,* Linn.) with oil is rubbed over the splenic region, which may be cupped or simply scarred. The carrying of a written charm and design called the Prophet's sandal, and the principle of bending to put on the right shoe and take off the left shoe first (as practised by the Prophet) is also deemed a method of prevention.

Exanthems

1. *Small pox.* The following is from the report of a local Hakim: "The patient must be isolated, and precautions taken against spread of the disease by contact with other people. He must be neither washed with water nor rubbed with fat, and must smell no fragrant smell, perfume or spice. His diet consists solely of milk."

Treatment of exanthems

2. "*Vaccination.*" Direct from the patient to the healthy (inoculation) is practised, as instanced at Nahud last year, where twenty-five children were so treated by the local Hakim from a suspected case, which, however, proved not to be one of smallpox. None of these twenty-five "took."

3. The use of *onions* in smallpox. When the pustules make their appearance, the patient is to be given onions to eat in quantity during the day—this prevents the pustules spreading to the mouth. A drop of onion juice is also put daily into each eye to prevent these organs becoming affected. During this treatment only milk is allowed as a diet.

4. *The Hot Sand treatment.* In cases of smallpox and other eruptive fevers the patient's body is buried entirely in sand, his head alone being left out. This treatment is undertaken at noon (when the sand is at its hottest) on three successive days for an hour daily. By this time all the pustules will have dried up. A milk and onion diet is prescribed.

5. *Measles and Chicken-pox.* As far as one can gather, little special treatment is adopted, the patient being simply isolated and placed on a milk diet; occasionally the body is rubbed with oil to "limit the eruption."

6. The *infectivity* of, and necessity for *isolation* in, exanthems seems to be well recognised.

Chest Complaints

Methods of treatment:—

Treatment of chest complaints

1. Half a rotl[1] of simsim oil (Sesame) (*Zeit Wad-el-Assara*) with salt to taste—drunk every morning and evening. This is considered soothing, and is decidedly purgative.

2. One quarter of a rotl gum arabic boiled with 1 rotl of water until the colour becomes red. This mixture is drunk every morning for a week, and no restriction of diet made.

3. One ounce powdered *Garad* mixed with 1 rotl of cold water to be drunk every morning.

4. Powdered *Tumra* root (Tamarind) mixed with milk and drunk every morning.

5. Garad. The fruit of the *Sunt* tree sucked fresh is a specific for coughs.

In all cases of chest trouble, scarring, cupping and cauterisation is resorted to over the thorax, commonly below the clavicles, or at sites of pain or swelling.

Leprosy

[Extract from my recent report on "Leprosy in Kordofan"]

Native treatment:—

Treatment of leprosy

The itinerant Falatahs are apparently held in considerable repute as healers. At Um Sheiheta I was shown a girl said to have been completely cured of leprosy by one powerful dose of an unknown drug, and some even more powerful exhortations at the hands of a Falatah Fiki; and certainly when I saw her she showed no signs of the disease, no matter what her symptoms may have been before. Some of the specific drugs also bear Falatah names in precedence to their Arab equivalents. The written charm or Ketab possesses the same quiescent remedial power in leprosy as it does in all other diseases and evils. As also the universal treatment known as Mahaia (polishing off), in which the patient eats or drinks the solution of the holy writ.

In leprosy, a verse from the "Suret El Ekhlas" (Chapter of Sanctity) is written a thousand times on Garad (fruit pods of the Sunt tree or *Acacia arabica*) or on small pieces of paper. A decoction is then brewed from these, drunk in large quantities and rubbed over the entire body "as a certain cure," with, however, no very startling results. The native, I think, in his heart recognises that the disease is incurable, though he does not appreciate its infectivity and ultimately fatal issue.

Nuba treatment:—

Nuba treatment

This has (round Murta and Kadugli), as its foundation, general scarification of the body, apparently with no relation to the site or extent of the lesion, and cupping of considerable quantities of blood, after which a decoction from the root of the *Buda* plant (*Striga hermonthica*, Benth.), or the bark of *El-Talh-El-Hamra* (*Acacia seya*), or a mixture of both, is administered in large doses and a course of warm baths or fumigation thrice daily indulged in. Decoctions, too, from the root of a Falatah shrub, termed in their tongue "*Akagod*," in the Arabic "*Kakada*" (*Dichrostachys nutans*, Benth.), is used, whilst for the local treatment of skin lesions, ulcers, etc., the powdered bark of the *Shagarah-El-Nar* (?) mixed with dried and powdered *Bamia* (*Hibiscus esculentus*, Linn.) vegetable leaves is applied, or, even better, the powdered leaves of a tree called *Likbalie* (?), which possesses the decided advantage of effecting a cure in three days.

[1] One rotl = 0·99 lb. or 450 grammes or 0·79 pint.

As a rather more expensive treatment, the blood of the Kharoof, or wild hog, may be applied externally and taken internally; as wild hogs are difficult to get, this method, though said to be efficient, is uncommon. Any form of treatment seems limited to those cases only where ulceration and open sores exist; before this stage curative steps are seldom taken, the easy-going Nuba trusting to his luck.

Arab treatment :—

Arab treatment

This differs but little from that of the Nuba, cupping is less indulged in, but scarring of the body in general and cauterisation round the larger joints seem to take its place, and the intellectual *Mahaia* treatment is more commonly practised. The roots of the *Shagarah-El-Nar*, *Akagod* and *Likbalie* are also used for local and internal administration, besides which copper sulphate mixed with oil may be rubbed on the body and small quantities of the same drug given internally with draughts of marissa. Well-to-do patients are sometimes provided with a tub of *Semn* oil (butter), in which they sit for an hour every day for seven days, whilst others are passed three times through the fire to cleanse them of the disease—an interesting custom which reminds one of the recorded usages in the worship of the god Moloch.

The simple faith of the native—who expects immediate cure, or, if this fails, abandons himself unreservedly to Kismet—excludes any prolonged treatment in this as in other diseases. A specified duration of fasts, courses, purges, and the like must either cure or leave uncured by the will of Allah in a specified time.

Other methods are :—

Other methods of treating leprosy

1. *During the early stages* the patient drinks no plain water, its place being taken by a mild infusion of *Garad* (fruit pods of the *Sunt* tree). His sole diet is of dry bread, with dried meat allowed every fifteenth day.

   He fumigates his body (over a burma[1] sunk in the ground) with the wood of the *Talh-El-Hamra* (*Acacia seyal*) or *Habil* (*Combretum multispicatum*) Engl. et Diels.

   This treatment is continued for 40 days, during which time attention is paid to general health and good digestion in particular. The patient must avoid smelling any perfume or pleasant smell; no very difficult matter.

   The disease is here attributed to an excess of blood, as evidenced by the discoloured patches on the body. The astringent infusion of *Garad* remedies this. Bleeding may also be resorted to.
2. The patient is isolated for 40 days, during which time no drug is given. His diet consists solely of goat's milk. Onions are strictly prohibited, as also the smelling of pleasant perfumes.
3. In severe cases—cauterisation of all the joints of the body. To this form of treatment is attributed many remarkable cures.
4. A Falatah treatment combining the medicinal and *Mahaia* methods is practised as follows: The root of a tree called *Ligna* (Falatah), *El Kulkul* (Arabic), (*Bauhinia rufescens*, Lam.) is dried and cut into small lengths, on each of which is written a Koranic verse, beginning "You who have faith." A special "Khatim" (a series of mystic signs arranged in the parallel sub-divisions of a square) is then written by the officiating Fiki on a writing board and, when dry, washed off. (Fig. 65.) The pieces of root are now placed in the resulting inky fluid and boiled for several hours, during which time the Fiki prays.

[1] Earthenware vessel.

The decoction obtained thus is administered internally and no other form of treatment allowed.

Gonorrhœa

Arab methods of cure:—

1. Powder separately—

℞ 3 oz. Gadda (Asafœtida)
3 oz. Natron (Surface salt)
3 oz. Shab (Alum)

Treatment of gonorrhœa

Mix together and dissolve in a quantity (?) of hot water. Dose—3 oz. daily. Diet—only soup and milk.

2. The fruit of the *Hanzal* (colocynth) is emptied of its seed through a round hole at one extremity. The resulting cavity is then filled with milk in the evening, which is allowed to stand all night, being drunk on the following morning. The same fruit lasts for three days, when if a cure is not complete another should be used.

3. *Kharasami* (worm seed), and *Sheeh* boiled in *semn*, and half a rotl of the mixture drunk every morning.

4. Injection into the rectum. A solution of *Abu Lebbru* (? *Boerhaavia plumbaginea*, Cav.) or *Ushar* bush fruit (*Calotropis procera*) is made and injected daily into the rectum through the perforated horn of a sheep specially constructed for the purpose.

5. The root of the *Kalto* (*Ximenia americana*, Linn.) ground and ½ oz. of the powder added to marissa and drunk every morning for three days. There often results considerable diarrhœa and vomiting.

6. The same drug added to water is used as a urethral injection, the natives using a tin syringe of *Sûk* manufacture, or a pierced horn.

Dangerous native treatment of gonorrhœa

The native treatment of gonorrhœa is not only ineffective but most dangerous. There have been three deaths in the Civil Hospital, El Obeid, during the last year from malpraxis in this direction, one from anuria, another from acute ascending nephritis, and a third from gangrene of the scrotum and penis. Each of these unfortunates had, prior to admission, undergone a course, resulting in severe vomiting, diarrhœa, and acute inflammation of the kidneys, with hæmaturia, the passage of blood being looked upon as an essential to the cure.

7. In the case of the patient who died from anuria, *Rabah* was the drug used (as indeed I suspect in all three instances). The two medical officers at present in El Obeid, El Yusbashia Saiid Effendi Ayoub, and Michael Effendi Zughayor, each report similar cases of death from *Rabah* poisoning, one that of a katib on the White Nile, the other a woman at Nahut; in each, severe nephritis was the cause of death.

8. Medicine No. 1, from *Sherkeila* (?). A root, powdered—1 dr. added to half a rotl of semn, or 1 rotl beef-tea taken every morning for three days.

The diet is important. Nothing should be eaten before noon; between noon and sundown, mutton; after sundown, anything except *Bamia* (elsewhere used as a cure for the same disease), which must be rigidly avoided.

9. Root No. 3, from *Sherkeila* (?). A root, powdered, and 3 dr. mixed with 3 oz. of soured milk, to be given every morning for four days consecutively.

Nothing should be taken before noon, and only chicken soup and plenty of water drunk after this hour.

This treatment is also employed for the cure of "Har Boul," burning on micturition common amongst Arab and Sudanese children, from the presence of gravel, and concentrated acid urine.

In most of these treatments for gonorrhœa, starvation seems to play an important part, as also drastic purging.

10. *Bamia*, a vegetable[1]—made into a pulp with boiling water and eaten.
11. Local fumigation is a common treatment in cases of gonorrhœa amongst women.

Syphilis

Treatment of syphilis

Tekhsheeb is the term applied to any course undergone for the cure of syphilis. After such a course the patient is called *Wahid Tekhshebt*. Every system varies in period, regimen, and the specific drugs used according to the methods of the Hakim adopting it.

1. For early symptoms:—

    Make a solution of *natron* (ground salt), one handful of salt to half a rotl of boiling water; mix this with half a rotl of milk and half a rotl of oil (semn). A cupful to be drunk every morning immediately before breakfast, which is not eaten until mid-day, the patient fasting up till this hour.

2. For secondary symptoms:—

    Treatment of secondary syphilis

    Mix 3 rotls of *Tureiha* (*Pterocarpus lucens*) in 6 rotls of water, leave standing in a burma for three days. Half a rotl to be taken every morning and evening for a week, during which time only dry bread and dura to be eaten, with no salt.

    After the first week, half a rotl of *semn* (native butter) to be drunk every morning and only goat's meat eaten, in addition to the bread and dura, with but half the usual ration of salt.

3. *Semn* treatment:—

    Consists in giving the patient half a pound of *semn* to drink every morning for a period of 12 days. Little care seems to be paid, as a rule, to the local treatment of syphilitic sores, ulcers and skin lesions in general, since they are supposed to be beneficial as an "outlet" for the disease.

4. The powdered root of the *Ghrur* (?) is used to sprinkle over old-standing ulcers (the ulcer surface having been previously freshened by scraping it with *shokh*—thorn), as also powdered *natron* (salt).

5. *Kursan*, fruit of the (*Boscia senegalensis*, Lam.) is used in like manner.

    One Hakim (Adrise Tahir Said by name) advocated only these external treatments without the use of any specific mixtures or restrictions of diet. He is, I think, the exception which proves the rule.

Drastic native treatment for syphilis

6. The treatment of one Mahd. Naial, whom I allowed to "cure" a patient suffering from advanced syphilis, was—

    ℞ 3 rotls of iron smelter's refuse, Khara Hadid (chiefly fused carbon, oxides of iron and arsenic ?)
    1 rotl Karkade (Red sorrel)
    1 rotl Tibet tree root (?)
    1 small burma of water

    These ingredients are all boiled together for 24 hours and kept warm for another 12. The resulting concoction, acid and nauseating in the extreme, is given to the patient (a large cupful) every morning for 40 days, and always administered hot. For the first 14 days the patient is put on a very light diet consisting of Kissera (bread) and water, no salt being permitted; for the rest of the "course" eggs, milk and a little meat are allowed (but on no account salt). Any local external treatment is strictly prohibited, and the patient is not permitted to bathe.

    The result of this treatment was most unsuccessful, the patient being so severely purged and, in consequence collapsed, that the Hakim fled in a fright after four days and has not since been seen.

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[1] *See page* 301.

This man also recommended decoctions from—

7. *Tiebra* root (?).
8. *Denobia* root (?).
9. *Daiu* root (?).
These being given with large draughts of water, and a liberal diet (but no salt) allowed. Neither must the patient be cupped, scarred, cauterised or his external lesions treated. Diarrhœa and vomiting often result. He admits these cures to be drastic, but at the same time considers them thorough.
10. Another treatment :—
Half a rotl of *Eshba* (Sarsaparilla) powdered and divided into 12 equal parts, one to be taken daily. The diet is to be light, chiefly dura, and no salt or vegetables are allowed. The patient is cured in 24 days.
11. *Sherkeila* No. 2. Root (?) powdered and 2 ounces taken with a little water every morning for five consecutive days. No food to be eaten until the afternoon, when a liberal diet is allowed.
12. Anti-syphilitic earth *(Tureba)*. Usually imported from the Nile; a variety also exists near Bara, where courses of a "sand cure" are undergone, the patient being buried in surface soil and taking it internally in the form of pills and in solution.

The points of interest in all these treatments are, I think, the universal avoidance of salt in the diet (such like *Tabus* are indeed common to many native systems of treatment), the restrictions of the morning diet, and the scanty attention paid to superficial lesions.

A great many "venereal disease" Hakims exist, most of whom do a brisk trade. The diagnosis of "Syphilis" is, however, very uncertain amongst them, many lesions, such as impetigo, psoriasis, etc., being clubbed together under this comprehensive heading.

"Wonderful cures" are of course reported on all sides, and the non-professional English official is quite convinced in many cases that the native Hakim possesses mysterious knowledge and drugs far superior to the mercury and iodides of the English physician.

Faranteet—Guinea Worm

Methods of treatment :—

Treatment of dracontiasis (guinea worm)

1. Powder 1 oz. dried castor oil leaves, add water until a doughy mass is obtained.

Fig. 78.—Nuba Pattens worn as a Preventive against Guinea Worm Infection—worn down by use

Place this as a poultice over the wound or inflamed area every night and morning. On removing the poultice wash the limb carefully with hot water.

2. Cauterise the site of inflammation with a hot iron in several places, through one of which the worm will afterwards present. This treatment is employed universally.

Use of pattens

3. The Nubas are convinced that guinea worm gains entrance through cuts or abrasions, or even through the uninjured skin of the feet. They are, therefore, particularly careful of their feet during the *Kharif* (the epidemic season for this disease), stand in stagnant surface water as little as possible, and wear a variety of high (often, when new, from 6 inches to 8 inches high) pattens, which are strapped on to the feet with strips of raw hide, when, of necessity, they leave their hills and have to travel in low marshy places.

   The two examples illustrated on page 307 and on this page were kindly secured for me by El Kaim. Wilson, Bey Mudir of S. Kordofan. These pattens are similar to the old English variety, and, like them, are used solely during wet weather, to raise the feet above the surface water. They should not be confounded with the clog or sabat, which is essentially a boot.

4. A pulp made from the freshly cut ends of branches from the *Tundub* (*Capparis aphylla*, Roth) tree may be applied to the inflamed area.

Fig. 79.—New and consequently high Nuba Protective Pattens

5. Three drachms of powdered *Gadda* (Asafœtida) are mixed in half a rotl of milk and drunk every morning until a cure results, the worm being left to extricate itself.

Mental

Treatment of mental disorders

1. Prayer. In cases of mania, etc. The patient being restrained by force, a Fiki or Fakir (holy man) is sent for to pray over him.
2. The *Mahaia*. Solution of written quotations from the Koran, at specified verses and chapters taken at intervals internally.
3. The *Azima*. Spitting over the patient's body is also resorted to.

   On asking a native Hakim his treatment for mania and mental disease in general, he replied: "There is no medicine for the disease save the name of Almighty God." This seems to be the general consensus of opinion.
4. *The Zarr*, or evil spirit, having once got a footing, a holy man replaces the Hakim in his endeavour to cure. The *Mahaia* and *Azima* are commonly resorted to, but more generally simple and prolonged prayer and the use of Kitub or written verses from the Koran folded up and tied with string round the elbow, neck or head.

5. As a cure in cases of giddiness, epilepsy and general mental weakness, *semn* may be rubbed into the patient's shaven scalp, over the forehead and within the nostrils, or the actual cautery applied either to the centre of the scalp or centre of the forehead at the point where it joins the scalp.
6. Another strange dietetic cure for such ills is the daily administration of a pigeon's head, which is plucked and eaten raw, *in toto* (brains, bones and beak) by the sufferer. As among most primitive people, various other meats are credited with medical properties influencing mind and body—thus the flesh of the porcupine to hasten delivery, that of various cats, the leopard, lion, &c., to secure strength, activity, and bravery, the jackal and fox for cunning.

Fumigation, Massage, etc.

1. *Fumigation.*

A universal custom, especially popular amongst Arab women, and indulged in from the point of pleasure, cleanliness and health. Fumigation

A burma (large earthenware vessel) is sunk in the ground, and in it placed glowing charcoal and the fumigant. Over this the person squats, enveloped in a *tobe* (cloth) so arranged that the smoke clings to the body without escaping. A single fumigation may last an hour or more.

The common fumigants are:

Sandal wood,	*Laban*
Talh wood,	*Bahour*
Subakh wood (*Combretum trifoliatum*, Vent.),	*Wad-Abiad*, etc.
Pepper seeds	

For medicinal purposes, too, various drugs, such as natron, alum, etc., and materials as cow-dung, hair, etc., may be added.

Fumigation is largely employed in syphilis (skin lesions), gonorrhœa (especially among women), and after child-birth to assist restoration.

2. *Massage, or dilka.*

Another universal custom amongst the Arabs in health and disease. Massage

A strongly-scented paste made from ground dura, marissa grounds, fat, oil, water and such aromatics as *fitna* (a complex Eastern perfume), *magmoa*, *surratia*, *zet sandalia*, and *baida*, to which various medicaments may be added where therapeutic results are aimed at. This paste is rubbed piecemeal over the entire body from head to foot, and gradually worked off with a strong kneading action. With it all dead epithelium is removed, and a refreshing "tone" given to the skin and muscles. Such procedure largely takes the place of our hot-bath, whilst in wasting diseases, fever, rheumatism, strains, sprains and the like no better treatment could be employed.

3. *Anointing* with vegetable oil, *semn*, ostrich and rhinoceros fats, also universal, is the more common practice amongst the Nuba and Bagara. Anointing

As a safeguard against the sun, *semn* or fat is smeared thickly over the scalp (especially amongst children). Certain Nubas also make a thick paste of flour and oil, which they rub into the hair, smooth down, and let dry into a perfect plaster-cast about an inch thick. This, dried white in the sun, contrasts acutely with their black skins.

Even with shaven heads, absolutely unprotected, the Sudanese seem to be able to stand any degree of light and heat without ill-effect, though I have seen one case of sunstroke in a Nuba following exposure after a debauch on meat and marissa. The native treatment is to put salt in the ears and bathe the head with water, to which may have been added the *Hagar-et-dam* or *Hagar-el-Akhdar*.

The Arab (except of the very lowest class—camel men, etc.) recognises that loss of mental power, intellect, and activity follows on constant cranial exposure to the sun. He is therefore more careful of his head. As regards the contented, unclad and lethargic Nuba, I imagine it would take centuries of straw hats to raise him above the intellectual status of his simian relatives.

Midwifery

Midwifery

Many of the following details having been given me by partially instructed midwives, it is difficult to determine whether some are purely local in origin or introduced.

The ease with which the ordinary Arab and Sudanese woman parturates renders the presence of a midwife almost unnecessary. At a birth, however, marissa is provided free, and the local matrons therefore appear in full force. They are after their fashion all more or less expert midwives, and apparently delight to discuss the pros and cons of each case at great length. The ease of head presentations, as compared with arm, and leg, etc., presentations, is well recognised, the more enterprising endeavouring to correct these positions by manipulation. In cases of maternal death, contracted pelvis, etc., I believe cæsarian section has sometimes been performed; more often, however, the child is crudely dismembered and removed piecemeal. This procedure caused not only the decease of the child but also that of the mother during a labour a few months ago at Kadugli, the woman being so severely mutilated that death from hæmorrhage occurred.

To assist labour, manual pressure is applied over the uterus, especially during the "pains," as also pressure over the sacral region from behind.

A piece of rope tied tightly round the woman's waist is another method to this end.

Treatment of difficult cases

Before the presentation of the head in the vulva it is almost always necessary to enlarge the aperture by cutting with a razor. When the head is emerging it is retarded manually, so as to prevent more extensive rupture. After child-birth the woman, if young, usually undergoes another restorative operation.

When the foot presents, it is either restored, in hopes that the head will take its place, or else the other foot is caught and brought down, traction being then applied vigorously together with pressure from behind and above.

If the hand presents, it is either restored or else left *in situ* and traction exerted.

Massage of the abdomen and slapping the abdominal wall is resorted to in cases of delayed pains and inertia; in cases of retained placenta, squeezing and pressure from above are adopted, as also, in post-partum hæmorrhage, pressure exerted over the abdomen.

The cord is tied four fingers' breadth from the umbilicus and cut one finger's breadth further down. It is said to fall from the baby in three days if the mother is giving much milk, otherwise in seven days.

Little or no after-treatment is employed, binders, douches, and the like being unheard of. This neglect of the baby accounts, I imagine, for the great frequency of umbilical hernia amongst Arab and Nuba children, a deformity popularly attributed to the witch Um-El-Sibian.

One midwife claimed to be able to prognose a girl or a boy by the fact that, if there be a girl *in utero*, a blue vein appears on the mother's abdomen, extending from the umbilicus to the pubes. If a boy this vein extends from the epigastric region to the pubes.

Cleanliness is considered quite unnecessary in conducting a labour. There is, however, in spite of this, little puerperal septicæmia, etc.

There is a Nuba custom that when a woman is pregnant for the first time, at about the fifth month, she is scarred in a rough pattern all over the arms, body and thighs. This they call their (*tahur*) "circumcision." If a woman remains barren, no "circumcision" is performed until she reaches the menopause.

In cases of inertia the Sudanese midwife and an assistant shake the patient violently by the shoulders at intervals to hasten matters, sometimes with unforeseen results.

During child-birth a large assortment of charms are worn, around the neck, breasts and flanks and also attached to the angerib. A design of the Prophet's sandal may also be hung on the wall for the labouring woman to look towards for assistance.

Death in utero, etc.

Death *in utero*, etc.

Abortion and death *in utero* are ascribed to evil influences, such as the evil eye, Um-El-Sibian, or the jealousy of another woman, who will then procure charms to such an end from the nearest Fiki.

Should a woman menstruate during pregnancy, the expected child is considered dead, or in a state of suspended animation, in which condition it may remain for years without being delivered.

Through evil influence, too, full-term children may remain alive *in utero*, being felt to move but showing no anxiety for delivery. One case is recorded in which this condition lasted for 17 years, during which time the ever-expectant mother spent most of her savings on worthless charms and remedies!

In these cases of suspended birth and animation, should the husband absent himself for a period of months, on re-cohabitation the child may return to a natural state and eventually be born, already somewhat advanced in years.

Significance of the scalp lock

The solitary lock of hair on a clean-shaven head called Gurin, Gambour or Guaga, worn by many male children and adults, is supposed to adorn that part of the head which first presented during birth (it is indeed commonly situated in the right or left occipito-parietal region), the exact locality being carefully recorded by the midwife present at the time.

It is allowed to grow:—

1. During babyhood as the token of a vow made during pregnancy by the parents, that should a boy be granted them they will not shave the Gambour until they have sacrificed to some saint, Fiki, or the like.
2. In the child, it is preserved as a convenient handle for angels to lift him out of harm's way in case of necessity.
3. In youth it may be retained solely as an ornament.
4. In later life again it may be re-grown as the token of a vow on the part of the wearer.
5. Some carry it as a safeguard against the heat of the sun.
6. Whilst certain Fikis and holy men wear it as a badge of office.

I have read that a similar scalp lock worn by a certain tribe of North American Indians is considered by them as a protection to the soul. Should it be removed by an enemy, the soul thus exposed is at the mercy of the operator.

ARAB AND SUDANESE SURGICAL INSTRUMENTS (KORDOFAN). *(See pages 313 to 317)*

1, 2, 3, 5. El Samandia 4, 7. El Murwad 6. El Reisha 8. El Mikhray 9. El Ishfa 10, 11. Thorns for scarification purposes 12. El Kamaia 13. El Lazim 14. El Fass 15. El Saleeha

Surgical Instruments

Plate XLIII

The following are the more universally employed surgical instruments and appliances in Kordofan.

Snare

1. *El Saleeha.* A snare, simply constructed from a piece of dry dura (millet) stalk, about 6 inches to 9 inches long and a stout giraffe tail hair. One end of the hair is firmly bound to an extremity of the stalk, its free length being then looped back and passed through a perforation, traversing the stalk obliquely from the centre of its extremity to a point 1 or 2 inches lower down, where it emerges to be used as a tightening string.

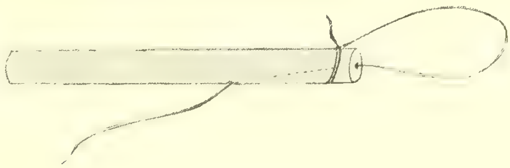

Fig. 80.—El Saleeha

It is employed to catch and draw forward the uvula, for excision with a knife or pair of scissors. A sharp-pointed iron hook (Ishfa) may be used for the same purpose. (Fig. 88.)

Scalpels and forceps

2. *El Samandia.* A narrow length of iron about six inches long, fashioned as a forceps at one end and as a scalpel or probe at the other. It is used for all minor operations, such as blood-letting, scarring, opening abscesses, removing thorns, etc.

Two such, together with a long native needle, are frequently carried in the sheath of the Kordofan knife, ready in case of necessity. (Fig. 86.)

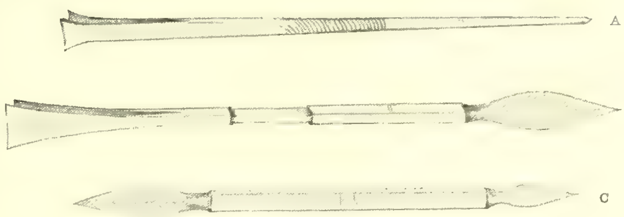

Fig. 81.—El Samandia

There is another variety armed with a blade at either end. (Fig. 81, C.)

3. *El Lagat.* Somewhat similar to the *samandia*, being provided with a forceps at one end, while at the other there is a double prong instead of a single point. This prong is used to remove dead tissue and to stimulate and freshen dirty or granulating surfaces. (Fig. 82.)

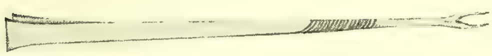

Fig. 82.—El Lagat

Probes and scrapers

4. *El Reisha.* A short scalpel with a small acutely pointed blade, which is triangularly notched at its extremity; the handle ends in a blunt probe (*murwad*). This instrument is used for scarring, vaccinating, and for the removal of dead flesh — the notched extremity acting as an efficient scraper. (Fig. 83.)

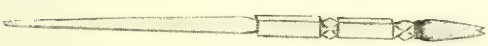

Fig. 83.—El Reisha

5. *El Murwad.* An instrument shaped as a blunt probe, fashioned of wood, ivory or iron, used to separate the glans penis from the prepuce and also to push back the glans before applying a clamp. Some are perforated at one end for use as coarse threading needles. (Fig. 84.)

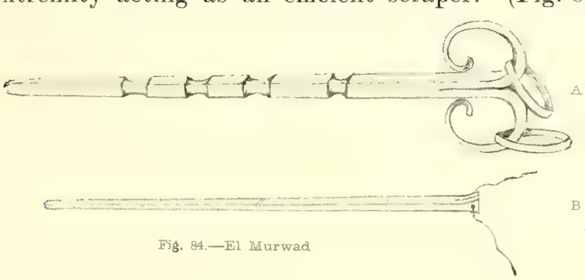

Fig. 84.—El Murwad

Knives

6. *El Muz.* Native razor for circumcision of males and females, and various other operations, is a short (4 inches to 6 inches) spear-head shaped knife welded from a single piece of iron. Before use a piece of cloth is wrapped round the handle to give a better grip. The blade is cleverly welded on the hollow and extremely sharp. (Fig. 85.)

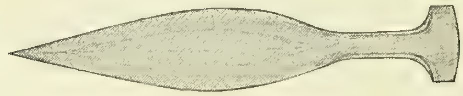

Fig. 85.—El Muz

7. *El Sakin.* The Kordofan knife (worn at the bend of the left elbow), alluded to above as carrying in its sheath the *samandia*, needles, etc., is also used itself in the rough native operations on both man and beast, besides being the universal weapon in all cases of

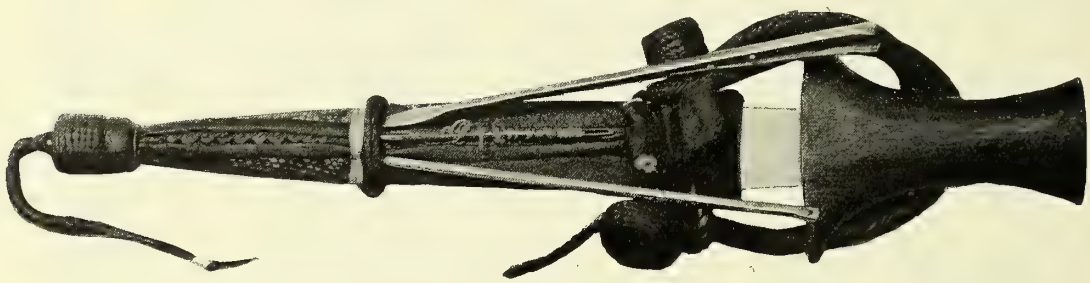

Fig 86 —El Sakin

necessity. It is kept particularly keen and well-pointed. Written and herbal charms are frequently attached to the sheath for convenience and safety. (Fig. 86.)

8. *El Sef.* The ordinary sword is used for amputations of the larger limbs in cases of surgical necessity and for punishment.

Setons

9. *El Mikhray.* A sharp-pointed piece of iron with a wooden handle, used in puncturing the skin for the insertion of setons. A fold of skin is picked up between the finger and thumb, pierced, and a horse or giraffe-hair passed through and loosely tied, a procedure almost identical with the European methods of a past generation. This treatment is employed to relieve inflammations, especially of the eye when the seton is inserted at the outer angle of the orbit, a custom still in vogue among some of our more antiquated ophthalmic surgeons. (Fig. 87.)

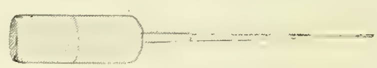

Fig. 87.—El Mikhray

Hooks, blunt and sharp

10. *El Ishfa.* A small blunt-pointed iron hook on a stem about five inches long and supplied with a wooden handle—it is used in operations for opening up the vulva before marriage and child-birth, the hook being passed under and caught in the thin scar tissue which occludes the vaginal orifice; traction is then exerted in an outward direction, and the semi-circular piece of skin, thus brought into prominence, rapidly removed with a single cut of the "muz." After such an operation a smooth cylinder of wood may be worn within the vulva to prevent the raw surfaces completely uniting.

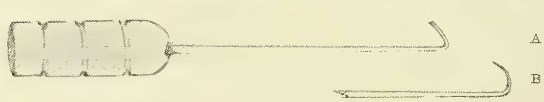

Fig. 88 —El Ishfa

Another variety of *Ishfa* is provided with a sharp hook to impale and draw forward the uvula during removal of that organ. (Fig. 88, B.)

Circumcision clamp

11. *El Lazim.* A clamp to hold the prepuce and exclude the glans during circumcision. It is constructed of two roughly curved jaws of sheet iron, each about 6 inches long, and pivoting at one end on a hinge, the free extremities acting as handles. (Figs. 89 and 96.)

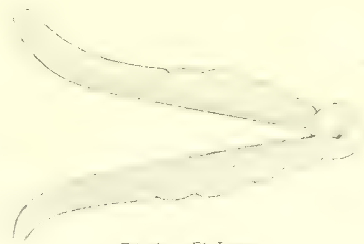

Fig. 89.—El Lazim

11 (*a*). Other instruments for the same purpose are small perforated discs of ivory or gourd, the lumen of which will just admit the prepuce without admitting the glans, or two lengths (6 inches) of thin pliable wood tied together at either end which include the prepuce clamped between them. (Figs. 98 and 99.)

12. *El Fass.* Consists of a length of dura pith (2 inches to 3 inches) attached to which is about a foot of soft cotton string. It is used in male circumcision, the pith to push back the glans whilst the string is tightly wound round the prepuce above its (the pith's) extremity, the knife being carried down between the tieing cord and the fass. (Fig. 97.)

Cauteries

13. Various forms of rough burning irons exist, having wooden or horn insulating handles. Needles are also used for the same purpose, and preparations of dry woods and pith. After cauterisation Gotran oil or lime is placed as a dressing over the burnt area.

14. *El Kamaia.* Primitive instrument used for cauterisation, consisting of a piece of camel's- or sheep's-dung dried and impaled on a long thorn. The dung is placed over charcoal until it smoulders, and then applied to the skin. (Fig. 90.)

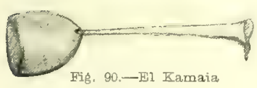

Fig. 90.—El Kamaia

Curette

15. *El Malahga.* A small iron, or wooden, spoon used for the removal of wax or foreign bodies from the ear. Sometimes suspended to the rosary for convenience sake. (Fig. 91.)

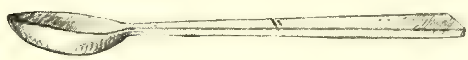

Fig. 91.—El Malahga

16. *Eye Dusters,* consist of small probe-shaped pieces of wood, ivory, or iron provided with a handle.

Fig. 92.—Eye Duster

Pieces of green fibrous twig, macerated at one end so as to form an improvised brush, are similarly employed. In eye applications the powder, ointment, etc., is smeared along the palpebral margin, and a surplus left amid the lashes, for gradual distribution between the lids. (Fig. 92.)

Tooth forceps

17. *El Gift. Forceps,* as used for the extraction of teeth, are usually borrowed from the silversmith and apparently form no part of the Hakim's stock-in-trade. Some of the more enlightened know of and are anxious to obtain European dental forceps.

18. *European Razors, Knives, Scissors, Needles and Syringes* are now largely used for various operations, to the exclusion of more primitive native instruments.

Cupping instruments

19. *El Mihgam (native Cupping Instruments)*, manufactured of metal or horn (Fig. 93). A is a small aperture provided with a soft leather valve. The site for cupping having been selected and scarred, the mouth of the cup B is greased and held in position, whilst the operator exhausts the air from the cavity C by suction. An ordinary small metal cup without aperture, in which the air is rarified by burning a piece of paper or rag within it, is also used. Professional cuppers and blood-letters are to be found in every large *sûk*—their half-naked victims seated around in groups, with *mihgamat* hanging on to their

Fig. 93.—El Mihgam

flesh like limpits. Cupping is a universal procedure for the cure and prevention of almost all ills, in much the same manner as was the vogue in England during the last century, and possibly borrowed by the west from that "most perfect physician," the Arab. Favourite sites are the back of the neck, the thorax, and front of the abdomen, and any locality of pain. It seems almost essential to let blood before the commencement of the *Kharif* (rainy season), as, indeed, at all times on the slightest provocation. The scars, which are rudely dressed and leave lasting marks, can be detected in number on any Arab's body.

20. *Injection horns.* The perforated horns of sheep and cattle are used, I believe, for the administration of rectal and urethral injections. I have so far been unable to obtain examples of these, but imagine they are much the same as, if not identical with, the *mihgam* or cupping horn.

Native splints

21. *Tabat*—native splints—consist of varying narrow lengths and sizes of split cane or other light wood, each piece being notched at either extremity for the attachment of tieing strings (12 inches to 18 inches long). These splints are arranged and used in sets of four, distributed at equal intervals around the circumference of the broken limb, over the site of fracture; rough padding of cloth or wood fibre intervenes between the skin and the splints, which are secured in position by means of the tieing strings and a couple of lengths of bandaging cloth firmly fastened over all.

Such splints serve in some degree to steady the fractured bone and in consequence to lessen pain; for the same reason adjacent joints may be included and thus immobilised. Reed-grass, tree-bark, and fine twigs are also used to encase broken limbs.

Splints are usually worn for a period of from two to six weeks, and during this time seldom re-adjusted; considerable deformity and fixation commonly result, especially in fractures of the lower extremities.

N.B.—My attention has since been drawn by Mr. Henry S. Wellcome to an article, "The most ancient splints," by Dr. G. Elliot Smith, M.A., F.R.S. (*British Medical Journal*, March 29th, 1908), in which the author describes two sets of splints found, still *in situ*, on mummies of the fifth dynasty (roughly 5,000 years ago) at Naga-Ed-Der (100 miles from Luxor). There is a most striking similarity in the construction of the ancient Egyptian and these modern Sudanese splints and in their mode of application, as may be

FIG. 94.—NATIVE SUDANESE SPLINTS APPLIED TO FOREARM

gathered from the following extract:—"The broken limb is set with four splints. . . . . Each consisted of a rough, slender strip of wood, which had been wrapped up by means of a carefully-applied linen bandage before being fixed to the limb. The splints were held in position by means of two bandages, each tied in a reef knot, one above, the other below. . . . . "

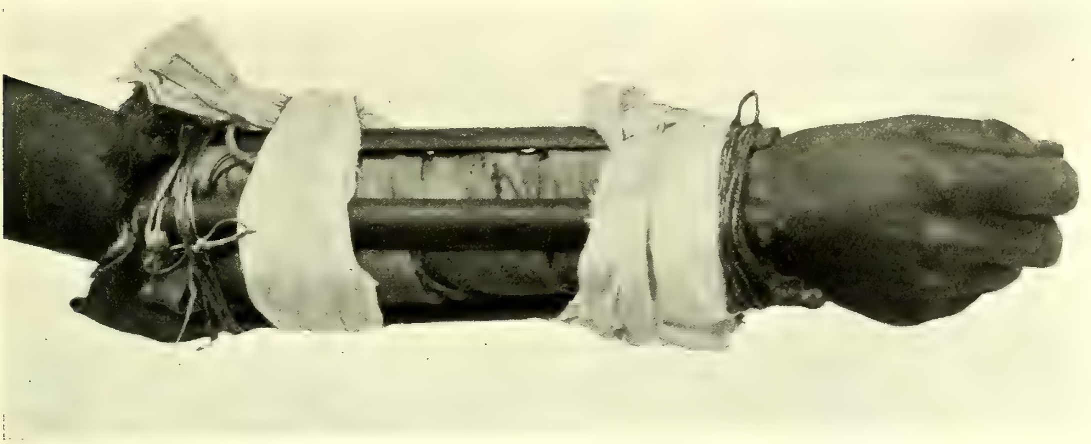

FIG. 95.—NATIVE SUDANESE SPLINTS APPLIED TO FOREARM

The materials used (four strips of wood, coarse grass, wood fibre, bark and cloth bandaging) as described by Dr. Elliot Smith, and their method of use in the two instances (ancient and modern) seems to be almost identical. The same methods, too, apparently still prevail in modern Egypt and in Abyssinia. As the author says :—" . . . a striking testimony to the stability of this idea, as well as of the extreme conservatism of the Egyptian. . . . . "

WOUNDS

The ordinary treatment of wounds (accidental) is extremely primitive. Few think it advisable to wash the part, and many consider such a procedure most dangerous, as exposing the patient to the risk of blood poisoning (which, when the quality of the water used is considered, is by no means unlikely). The usual aim is to secure a large clot or scab over the raw surface, and for this purpose powders made from Kohl (black antimony), Natron (ground salt), Gotran (colocynth tar), Shab (alum), Lime, Gulum, Shatta, Senna, Kursan, Ghrur, Shagar-en-nar, Likbalie, Thal, etc., are used as dusting dressings, as also the less pharmacopœial remedies Shourour (wood ash), powdered charcoal, sand, ground Durra, and camel-, sheep-, and cow-dung (often charred), the results being more or less satisfactory. I saw one case of tetanus following such treatment in a Nuba, but rapid secondary union is the rule, and septic complications rare, thanks, I imagine, largely to their strongly germicidal constitutions. Should such result, cupping, scarring, cauterisation, and more rarely poulticing in the neighbourhood of the inflammation are resorted to. Treatment of wounds

OPERATIONS

1. *Excision of the Uvula.* The uvula, "Reesha" (feather), is looked upon by the Arab as the primary cause of most chest troubles and inflammations of the pharynx and larynx, etc. The doctor therefore advises its excision as a preliminary measure in such cases. Young children have the operation performed as a safeguard to their health, especially before the *Kharif*. It is surprising the large percentage of people who are without uvulæ on these accounts. Excision of uvula

Operation. The uvula is snared by means of a Samandia or impaled on an Ishfa (*see* Surgical Instruments, *page* 313), pulled downward and forward and cut off with a scissors or knife, no after treatment being employed.

2. *Nasal Polypi.* "Um Sogah." If they come within sight, are scarred and punctured with the long thorns taken from a Heglig tree.

Circumcision of boys

3. *Circumcision of Boys.* Usually undertaken about the fifth or sixth year amid general festivity; visitors from outside villages attending, carrying with them presents in the shape of food, etc.

Usually several are circumcised at a time, the operator being the village Hakim, who is paid according to the standing of the boys' parents.

Operation. The penis is washed in cold water, after which a blunt probe of wood, ivory or metal (El Murwad) is passed round the glans, freeing it from the prepuce.

Fig. 96.—El Lazim *in situ*

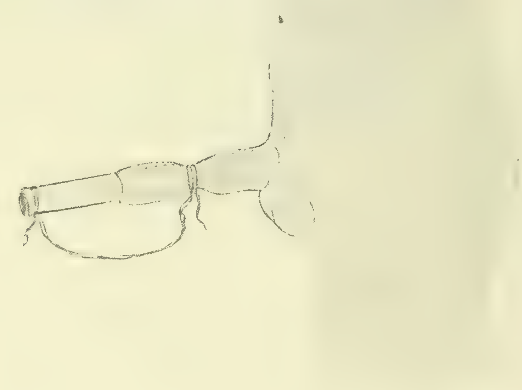

Fig. 97.—El Fass, showing method of use

Fig. 98.—Wooden clamp *in situ*

Fig. 99.—Gourd or ivory perforated discs and method of use

The prepuce is then pulled well forward and clamped by means of a "Lazim," a wooden clamp or the string of a "Fass," or drawn through the ivory or gourd disc (shown under the heading "Surgical Instruments"). After a few minutes, when the circulation has been thoroughly retarded, the skin is divided with a single cut of a sharp knife or razor.

In other cases only a single knot of string is used to retract the glans and retard the circulation, or again no constriction is employed at all, the glans being simply pushed out of the way by means of a murwad and divided with a circular cut. Sometimes the operator, using no instrument save a knife, inflates the prepuce with his lips and cuts it off rapidly. The Jewish custom still in vogue of biting off the prepuce is apparently not employed.

The prepuce having been removed, the clamp is loosed (if one has been used) and there ensues little or no bleeding. The mucous membrane is then retracted and sutured to the skin in two or three places by means of giraffe hair stitches, or, more commonly, fine sharp thorns, prepared in separate dishes (commonly small gourds or clam shells) of boiled butter, which are passed through the mucous membrane and skin and then broken off short. Often the mucous membrane is simply retracted and no sutures applied.

Fig. 100.—Circumcision thorn sutures *in situ*

After the operation the wound is dusted over with either ground charcoal, wood ash, ground dura, "Hankank" or "Karkarab" (a powder made from cotton seeds) or charred cow- or sheep-dung. The boy is then placed in a bed laid on the floor of a special tukl, his clothes being kept off the wound by means of a string suspended from the roof. His diet is at first restricted, but after three days, when the sutures are removed, he can eat as he pleases, and on the seventh day is discharged. The Hakim visits his patients daily, dressing them when necessary.

During such an operation the greatest excitement prevails, a mob of friends and relations crushing in to get a better view. The patient is usually provided with a whip, which he waves in his hand the while as a sign of courage. He seldom utters a sound, and I imagine the pain is but momentary.

Circumcision of girls

4. *Circumcision of Girls.* Usually undertaken at the age of five or six and attended by much less ceremony than in the case of boys.

The girl is placed on an angareeb[1] in a tukl, and the parts well washed with water. Assistants hold her down and keep her legs apart whilst the "Hakima," an old woman—or, in some cases, an old man—operates.

The clitoris is caught between the finger and thumb and severed rapidly with a sharp knife or razor, and after this each of the labia minora in turn. Some prefer to remove all with one sweep. Very hot water is then applied as a styptic and a dusting of one of the following:—

(*a*) Powdered natron.

(*b*) A paste of powdered dura and water.

(*c*) Alum.

(*d*) "Shish," a charcoal mixture.

The legs of the patient are tied together after the operation for seven days. She is dressed daily, alum and water being used as an astringent and antiseptic lotion. Sometimes, a small cylinder of wood is inserted into the vulva to maintain a urinary passage.

[1] Native bedstead.

The operation will not prove a success unless sufficient cutting has secured a complete secondary union, extensive enough to exclude the entire vulva, with the exception of an aperture only large enough to admit the little finger with difficulty.

Where only the clitoris and labia minora are removed the operation is termed "Tahuret Sunna," and is that prescribed by the Mohammedan law. This is, I believe, the vogue amongst Egyptian women, but in the Sudan it is mostly restricted to the Bagara tribes (Mesareah, Hommr, Habanea, Rezigat, Howazma, Gimma, etc.), whilst amongst the remaining Sudanese Mohammedans the more radical "Tahuret Farohen" is performed, in which the upper two-thirds of the labia majora are also removed.

The "Tahuret Farohen" is of interest since it is popularly supposed to denote an ancient method practised in and handed down from the time of the Pharaohs, which has survived in the Sudan despite the innovation of Muslim law.

A few tribes, I believe (amongst the Nomad camel owners), only remove the clitoris, leaving the vulva otherwise intact, whilst others, who have but feebly adopted the Mohammedan religion, or who still practise a religion of their own, do not circumcise at all—notably in Kordofan, the Nubas.

Special operations

5. *Opening.* An operation performed on the wedding-day. The bride is placed in a tukl and laid on an angareeb. The Hakima, attended by female relatives, enters and divides the old scar tissue centrally from behind forwards, an ishfa (blunt hook) being commonly used to render prominent the site of operation. The blooded razor or knife is afterwards exposed to the gaze of the assembled guests. This operation is sometimes performed by the husband himself, who in any case is provided with a knife or razor to carry out any further alterations he may find necessary.

When the scar has been opened, hot water is applied and a dusting powder, commonly of salt. Micturition and coitus are of course extremely painful, and the first few days of married life far from pleasant.

6. *Opening at Child-birth.* Owing to the mutilation consequent on circumcision it is almost invariably found necessary to enlarge the vulva during child-birth by means of the knife.

7. *Re-closing.* Young divorced women and widows who wish to regain their virginity frequently submit to a second operation. They are after this, of course, far more eligible and demand a higher dower.

These "patchwork" operations are, needless to say, unaccompanied by any display, as are the circumcision and bridal ceremonies.

The Arab saying, "Woman is as a girba,[1] we sew her up, open her, and fill her as we please," if somewhat crude, is indeed not without truth.

Amputations

8. *Amputations*—of the large limbs. Such operations are not unnaturally only undertaken as a last resource.

The method is primitive. The patient is seated in a chair. One assistant holds the limb above the site of amputation, another fully extends it and exerts traction, whilst a third supports the victim from behind. The operator, armed with a heavy, keen-bladed sword, sweeps down with one blow and severs the limb from the body. The cut end is then dipped into boiling oil and tightly bound, so as to arrest the hæmorrhage. A dressing of salt, wood ash, charcoal or the like being applied later.

Should the patient be frightened (perhaps a woman or a child), he or she is placed within a tukl and the diseased limb thrust out through a hole in the straw side, the operation itself being conducted as above. I have never seen an amputation thus performed

[1] Leathern water-bottle.

and imagine it is, nowadays, seldom undertaken, sufferers coming from great distances to undergo such operations, under the influence of an anæsthetic, and at the hands of a more precise surgeon.

Nuba "circumcision"

9. *Nuba "Circumcision."* The Nubas, possessing a religion of their own and not holding the Moslem faith, do not circumcise their girls or boys.

They have a custom of scarring primipara during pregnancy with a rough pattern over the body, arms and thighs. This they call "Tahur" (circumcision). It is an honour accorded only to the barren after they reach the menopause.

Teeth extraction

10. *Extraction of Teeth.* The extraction of the lower incisor teeth of males is a tribal custom amongst the inhabitants of the Fur country to the west of Kordofan, and to a lesser degree amongst the Nubas to the south; it is undertaken at about the age of puberty and holds a somewhat parallel position to circumcision, "Tahur," amongst the Arabs. The interval left, as well as being ornamental, is considered useful for hand-feeding the weak or dying.

For the extraction a silversmith's pliers is commonly used, if it can be obtained. Otherwise, the world-wide custom of securing a string round the tooth, fastening the other end, and jerking the head until the tooth comes out, is resorted to. Adjacent teeth to a free socket are worked loose and extracted with the finger and thumb.

The Nubas gouge out the selected tooth with the head of a Kokab or pointed spear.

In order to allay pain and bleeding, a dressing of ash, alum or asafœtida is applied.

Nuba nose, ear and lip perforation

11. *Nuba nose, ear and lip perforation.* At an early age the under lips and the lobes of the ears of girls are perforated for the introduction of cylinders of white stone. For the reception of these (in the case of the lip) they often remove the lower incisor teeth.

A thick lip is considered a thing of beauty. They therefore encourage an unnatural hypertrophy by rubbing in irritants and repeated scarification. The Nubas of some Gebels prefer their women unblemished. The contrast between the natural and artificial appearance is often striking.

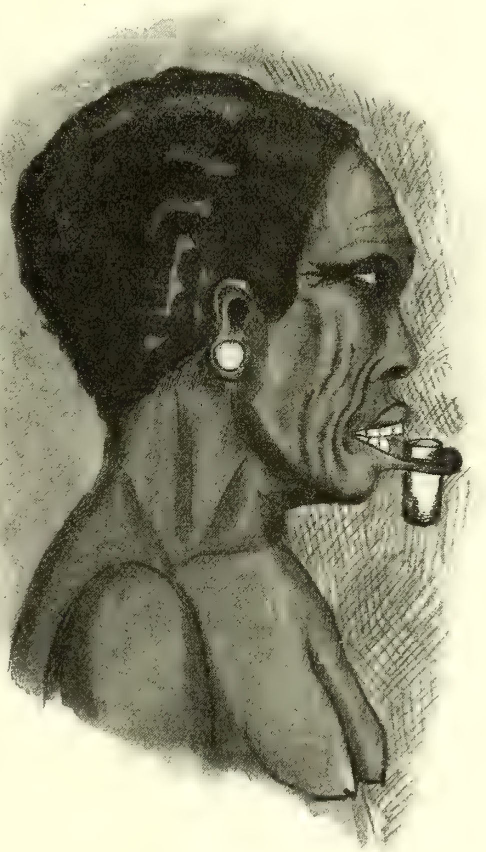

Fig. 101.—Nuba girl's lip perforated and containing a cylinder of white stone

Perforations of the nose and margins of the ears for the reception of rings, stones and iron spikes is a general custom adopted both by men and women.

Tribal marking

12. "*Tribal*" *marking*. Facial marking—which, as far as one can gather, seems to be undertaken with no very hard and fast rule as regards the relation of the mark to the tribe—is performed during childhood (6 to 10), the design being first traced on the face and then deeply scarred with a knife or razor. The wound is roughly dressed at intervals and may be powdered with antimony to produce a blue keloid.

The commonest facial markings are—

(*a*) Three longitudinal scars on either cheek.

(*b*) Three longitudinal scars and one transverse.

(*c*) Three transverse scars on either cheek.

(*d*) Two transverse scars crossing two longitudinal (called the Selim or ladder).

(*e*) Three scars in arrow shape (Darab El Tare or track of the bird), restricted chiefly to women.

(*f*) Two or three small scars, longitudinal or transverse, placed between the eye and ear on either side.

These are imprinted for custom's sake, sometimes apparently for cosmetic effect alone, or as signs, in some cases undoubtedly tribal, in others I imagine more "family," and as marks of possession and for identification.

Tattooing

13. *Tattooing*. Largely employed by Arab women for the supposed improvement of their appearance. In Kordofan the front of the gums and the lower lips are the only parts interfered with. The operation is undertaken, as a rule, during early childhood. The surface to be coloured is pricked with thorns, after which powdered antimony is rubbed in, a process which is repeated at intervals until a permanent dark blue effect (intensely repulsive) is gained.

Conclusion. As I have said, the major operation is a matter of last resource amongst these people. Most native surgery consists in the dressing of wounds and ulcers, the opening of abscesses and the like, scarring, cauterising and cupping, as surgical means to a medical end.

Then, again, there are the large percentage of religio-sexual operations for circumcision, the purely sexual plastic operations before marriage, and before and after childbirth, in women, and, lastly, the cosmetic operations—lip-splitting, tribal marking, and so forth; from which it will be seen that this branch of healing is not far advanced.

In conclusion, I wish to express my indebtedness to El Yusbashi Michael Eff. Zughayor, of the Egyptian Medical Corps, for much valuable assistance and information.

A. MacTier Pirrie

Fig. 102.—Ceremonial Dance

A MacTier Pirrie

Fig. 103.—Dr. MacTier Pirrie's Caravan

FIG. 104.—ALEXANDER MACTIER PIRRIE

"The death took place on November 12th, 1907, at the Chalmers Hospital, Edinburgh, of Alexander MacTier Pirrie, B.Sc., M.B., Ch.B., his life being thus cut short just at the time when he had laid what seemed the sure foundation of a career of much scientific distinction. He was a son of the late Alexander Pirrie, C.E., and, after the completion of his general education, became an undergraduate of the University of Edinburgh, and in 1904 received the degree of B.Sc., taking honours in Anthropology. Two years later he received the M.B., Ch.B. from the same University. He was then appointed Carnegie Research Fellow in Anthropology, and at once went out to the Wellcome Research Laboratories, in Khartoum, in Upper Egypt, in the position of Anthropologist to that Institution. Soon after his arrival he began a series of scientific expeditions, and completed two in the short period of seven or eight months that he was able to remain in Egypt . . . All must regret the loss of one whose early career seemed to suggest that it would be his lot to add considerably to the sum of existing knowledge."—*British Medical Journal.*

Report upon the Physical Characters of some of the Nilotic Negroid Tribes

BY

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From the Anthropological Laboratory of Edinburgh University

The late Dr. MacTier Pirrie went out in the autumn of 1906 from Scotland to Egypt, in order to undertake Anthropological work among the tribes of the Sudan under Dr. Andrew Balfour. The late Dr. Pirrie

Dr. Pirrie's training in Anthropology had been acquired in the Anatomical department of the University of Edinburgh, and a Carnegie Research Fellowship in Anthropology was awarded to him for the proposed research in the Sudan.

Early in October, 1906, he arrived in Cairo, and, after spending a short time there in making preparations, he went on to Khartoum, where he arrived on the 18th October. In Khartoum he at once began anthropometric work by taking measurements of students in the Gordon College, of soldiers in some of the native regiments, and of some natives in the prison.

At the same time preparations were made for an expedition up the Nile to study the primitive indigenous tribes of the Sudan.

The tribes among whom the work was to be carried out included the Dinkas, the Shilluks, the Nuers, and also the Buruns—a tribe of modified Negroids found between the Upper Nile and Abyssinia, five days' journey inland, of whom practically nothing has hitherto been known. Tribes visited

Dr. Pirrie's plan of work was to travel among these various tribes and to make observations on their languages, customs, dress, etc., and in addition to carry out an extensive series of observations on their physical characteristics, including measurements of the head and face, nose and limbs, and also to take impressions of the hands and fingers and of the soles of the feet. Plan of work

Dr. Pirrie unfortunately did not survive to work up the extensive material which he had in this way obtained, and the loss which was entailed by his sad death is a severe one, and in many ways irreparable. The cards on which the records of the various measurements had been made were handed to me in order to find out whether they could be made to yield any results of value. I have also seen a large number of the valuable photographs which Dr. Pirrie had taken, and some notes and jottings which he had made on the way were also put at my disposal. In regard to the language, it was found quite impossible to go into the various dialects and languages, nor was it possible to make an entirely complete examination of the physical characters. Death of Dr. Pirrie

As a result I have not been able to take up all the threads of his work and to weave them into a complete memoir on the indigenous tribes of this portion of the Sudan, nor could this work have been done by any person except by Dr. Pirrie himself.

The notes on language and customs were fragmentary, but fortunately the cards containing the records of the measurements were fairly complete.

Physical work on anthropology

Dr. Pirrie had obviously devoted a great amount of time to this part of his work, and his measurements were extremely numerous.

All the detailed measurements are not reproduced entirely in this paper, but I have examined and tabulated a very large number of the measurements, and tables of several of them, which may be taken as representative of the whole, are included here.

The field of his exploration, and especially that part which included the Burun district, has not been touched by physical anthropologists, and this fact alone gives to the data which he has secured a great additional value.

Account of Dr. Pirrie's Journeys

For purposes of convenience, I have sub-divided this report into two portions, the first of which includes Dr. Pirrie's report upon the journey which he made into the Burun district, with some additional notes, which he prepared after his return to England, upon some of the characters and customs of the Dinkas and Buruns.

The second part comprises some results of the investigations into the physical characters of several races, from the data which he secured.

Route followed

Leaving Khartoum on the 27th October in the Sirdar's yacht, on which he had been kindly offered a passage, Dr. Pirrie went south as far as to Renk, where he met Mr. Struvé. Renk he describes as "merely a tongue of land between two swamps, and the mosquitoes are simply black in the air." After a short stay there, during which he made some excursions into the surrounding country, he went on to Melut, returning afterwards to Renk, and making observations and taking measurements of the natives as he came across them. The next weeks were spent in carefully gathering together all available data as to the physical characters of the tribes in the neighbourhood, and in preparation for an extended expedition into the country of the Buruns. The tribes whom he was able to measure included Dinkas, Shilluks, Gebelawis, Fertits, and a few representatives of some other tribes.

The following account of his expedition into the Burun country is taken from his general report sent to the Sudan Government.

The only notes of anthropological interest in it are the following:—

"I left Melut, White Nile, on January 11th, 1907, and returned March 21st, 1907, having travelled through the Burun country in all directions, and made a circuit of it on the north and east sides.

"*Route.* The route adopted was the most direct one of going eastwards from Rengajuk. From Gebel Ulu the route lay by the chain of Gebels Mulke, Abdul-Dugal, and Koklik to Kaili, after which I returned south to Kurmok, then, passing westward through the country of the Currara, regained that of the Buruns. (*See* Fig. 105.)

"The tribes encountered in this journey were Burun, Hameg, Fung, Burta, Currara, and a small tribe of Arabs in the Curr district.

The Burun country

"*Extent.* The Burun country extends in a thin line from about fifteen miles south of Gebel Ulu to the Lakes Tigli and Worru; general direction south-east. It then spreads eastward and westward along the Khor Yabus and River Sobat.[1] Buruns are also found to the immediate south of the lakes mentioned. There also are four detached colonies of hill-living Buruns close to the Abyssinian frontier—on Gebel Wadaga, Ting-ying, Tartar and Funka. Buruns with well modified dialect are found on Gebels Abul-Dugal, Surkum, Kurmok, Gerrok, Myak and Muffe.

[1] This is not the main Sobat River, which lies far away to the south.

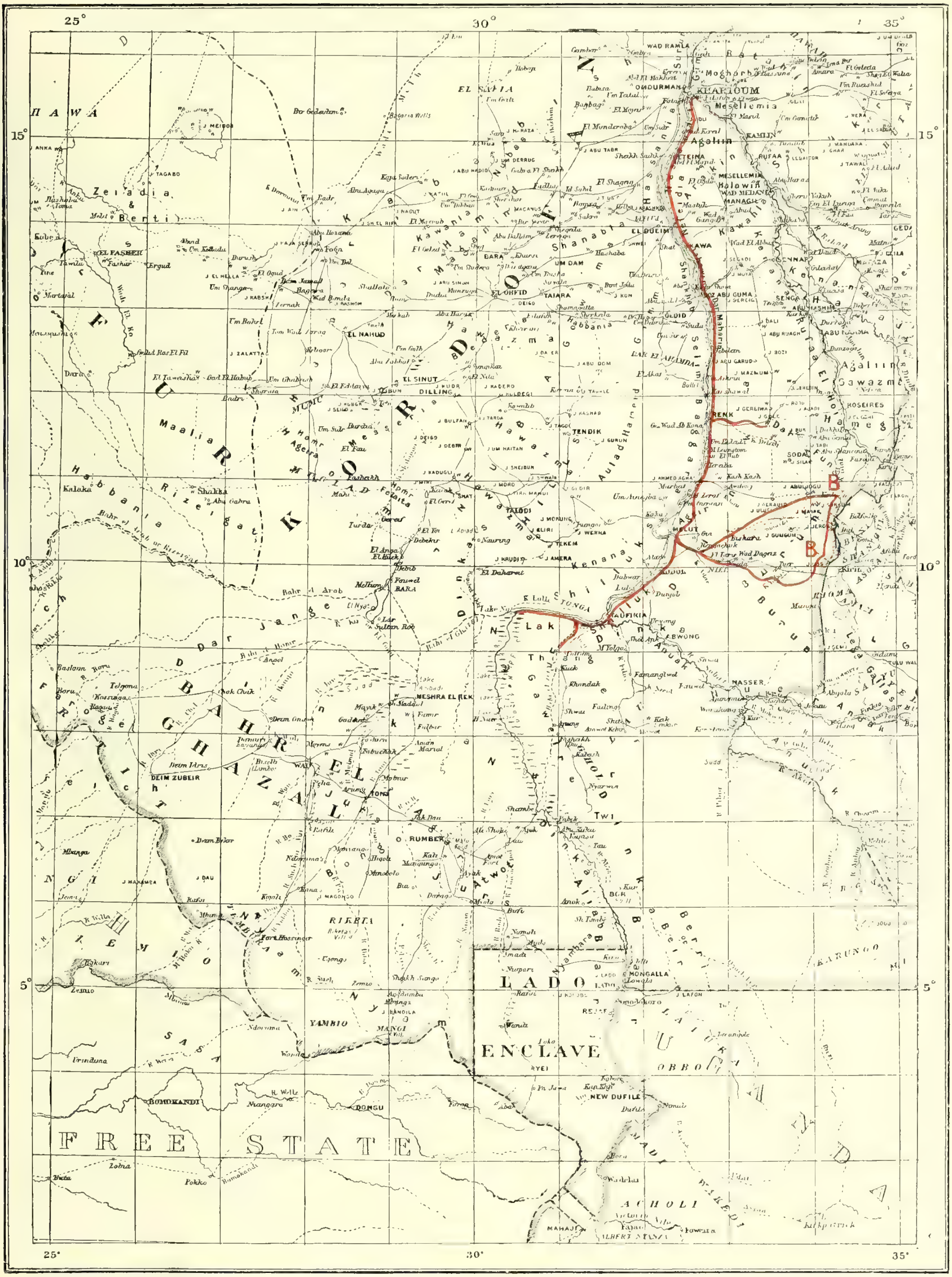

FIG. 105.—ROUTE FOLLOWED BY DR. MACTIER PIRRIE. BB = LIMITS OF BURUN COUNTRY VISITED BY HIM

"*Geographical Features.* The chief feature of the country is the pair of lakes called Tigli and Worru. The name Dora is better known, and refers to the villages on their northern bank. Lake Tigli is about half a mile and Lake Worru about a mile, square. Each lake has a high bank about 15 feet to the northern side, but they tend to fade into marshland to the south. The lakes are of the nature of diverticula on the Yabus and Sobat Rivers. (Fig. 106.)

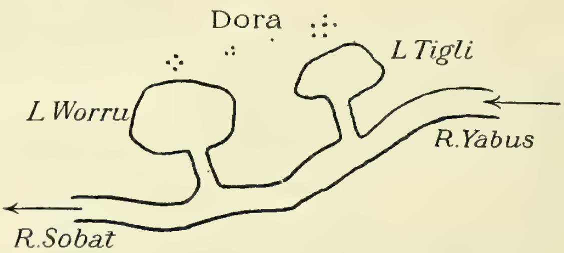

Fig. 106.—Sketch showing chief geographical features of Burun country

"The river called Sobat issuing from the lakes pursues a general S.W. direction. It is 40–50 yds. broad, 3–4–5 feet deep, and flows about $3\frac{1}{2}$ miles per hour. After a short course it breaks up into a labyrinth of khors, from which one stream, called 'Lidigo,' issues. This is narrow (5–10 yards), deep (4–5 feet), and flows at about the rate of 3 or $3\frac{1}{2}$ miles per hour. The last I saw of this stream was at Mwalla, where it was running away almost due south, but natives report that it turns westwards again; it may be that this stream is that known at the other end as the Khor Adar, in which case the Yabus may be said to flow into the Nile. There is no other possible connection to the north.

"The natives reported that these streams never ran dry. This is probable, as at the time of my visit the rains were approaching and still there was a good volume of water. The Buruns themselves never use the water for navigation.

"*Neighbouring Tribes.* On the west, the Dinkas, separated by an open plain of 2–$2\frac{1}{2}$ days. On the north the Fungs and Hamegs. On the south the Nuers, said to be 3 days distant. On the east the Currara, $\frac{1}{2}$ day; Burtas, $1\frac{1}{2}$ days; Abyssinians and Gallas, 2–3 days.

Condition of the Buruns

"*Condition of the People.* Except the northerly part of the tribe, the Buruns are sheikhless. They have not recovered from the effects of the raiding. There is not a head of cattle in the whole country, and their goats and sheep are of the poorest. They have few women, they are overrun with syphilis, and they offer poor resistance to disease. I passed through two epidemics of smallpox, which more than decimated them. In this connection it is interesting to note that they bury their dead in the floor of the hut, with what results may be imagined!

"The Buruns are addicted to merissa.[1] There is a system of merissa-meetings in neighbouring villages, by means of which each man attends about three in the week. Fighting is common at these orgies, the poisoned arrow being the usual implement employed. I consider that the lack of women has largely to do with their addiction to drink, facilitated by the superabundance of their grain.

"*Dialects.* The Burun dialect is more closely related to the Nuer than to the Dinka dialect. The Fungs speak the Burun tongue; the Hamegs speak Fung and Hameg, which is said to be derived from the Nuba. The Burta language is different from the Hameg.

"*Currara.* In my opinion the Currara are not Buruns, though I was informed at Kaili that they were administered under that name. Their dialect is totally different and may be allied to that of the Hamegs. I could trace no philological connection between the Currara and Burun tongues."

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[1] Merissa is a native beer made from dura (millet).

A. MacTier Pirrie

Fig. 107.—One of Dr. Pirrie's Camping Places

A. MacTier Pirrie

Fig. 108.—Burun Village

The presence of pigs may be specially noted

Physical Characters

Method of examination

The method of investigation into the physical characters, which was followed by Dr. Pirrie, is practically that which has been drawn up by the Anthropometric Committee of the British Association, and to that report I would refer any traveller who desires information on the best methods of carrying out such an examination of native tribes. The scheme of measurement includes an examination of the head, trunk, and limbs, and it is highly desirable that the measurements recommended by the Committee should be followed carefully.[1]

Physical anthropologists have been handicapped by the fact that measurements have not been made hitherto on a uniform plan by travellers.

Nilotic tribes

The Nilotic negro or negroid peoples are divided into many tribes, many of which are very large in size. They include the whole native population "extending from the western frontier of Abyssinia across the Nile Valley, through the Bahr-El-Ghazal region westwards to the Central Niger, and from about 200 miles south of Khartoum to the north-eastern shores of the Victoria Nyanza."[2] It is impossible to form an estimate of the total number of people included in this great area, for even the total number of tribes inhabiting it is unknown, and many of them are numbered by millions of individuals. Along the frontier of this vast region, the races show traces of intermixture with the natives of adjoining lands, the Abyssinians, the Hamites, the Bantu negroes, and the Hausas, and variations have arisen; but among the tribes in the central parts also differences in colour, stature, head-shape, language, customs, diet, and occupation are found. These differences are so marked that it is hardly possible to reconcile them with any theory of a uniform descent for all.

The travellers who have described the physical characters of these peoples include such well-known names as Speke and Grant, Petherick, Schweinfurth, and Sir Harry Johnston, and all of them agree in recognising tribal differences which are of the greatest value to the physical anthropologist. To the descriptions of these writers I am greatly indebted for additional information beyond that obtained from Dr. Pirrie's notes.

To what extent the tribes are remaining "pure" forms a very difficult question.

As in other parts of the world, the tendency towards intermixture is increasing, and more than one of the individuals measured by Dr. Pirrie owned to a mixed parentage—such as mother a Shilluk, father a Dinka. But it is not difficult at the present time to find individuals who illustrate in a pure and unmixed form the physical characters of the various tribes to which they belong.

When a series of such individuals is examined, even superficially, it is at once evident that there is hardly a single feature of physical character which is common to all of them. The stature varies within wide limits—"in this and in an adjacent part of Africa are found tribes who may be considered among the tallest, and others who are among the shortest of human beings, *e.g.* the Dinkas on the one hand, and the Akkas on the other."

In such an important feature as colour also wide variation is found, from the almost jet black of the Dinkas, Nuers, etc., to the reddish colour of the Bongos.

In shape of head the differences are less marked, and the majority of tribes show dolichocephalic characters, but, again, another condition is also found in other tribes, and a pronounced degree of mesaticephaly shows itself.

In length of face, in the degree of prognathism, and in the characters of the nose also, similar variations to a minor degree are found among the various tribes.

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[1] *Report of the Anthropometric Committee of the British Association*, 1908.

[2] Johnston, Sir Harry, "The Uganda Protectorate."

C. M. WENTON

FIG. 109.—HUNTING PARTY OF NATIVES ON WHITE NILE

C. M. WENTON

FIG. 110.—GROUP OF CHILDREN AT BOR

When these variations in physical character are found allied with differences of occupation, of customs, and of degrees of civilisation, it is difficult to believe that the tribes form a homogeneous entity, and it is obvious that no general statement, or only one on lines so general as to be almost valueless, can be laid down regarding the racial character of Nilotic negroes.

I shall therefore first of all take up in some detail the leading characters of the various tribes represented in Dr. Pirrie's collection of measurements.

The tables which are appended give the average measurements obtained from some twelve different tribes, and tables are also appended giving the detailed figures of the individuals in several of them. In one or two cases, measurements of representative individuals of the same tribe were made in different localities, and I have included in separate tables the measurements taken in different places, so as to determine whether the racial characters of the one tribe are constant in different localities. The individuals who were measured were, without exception, males, and their ages ranged from twenty to forty-five or fifty years.

In dealing with these measurements I have selected only a few for purposes of comparison among the tribes, and chiefly those which are already known to be of value to the physical anthropologist, such as head-form, stature, and characters of the nose, with, in some cases, reference to the length of the limbs.

In comparing measurements and indices from the living subject with those obtained from measurement of the dried bones of the skeleton, allowance must be made for the presence of the soft tissues. Thus, in the case of the head, it is necessary to subtract from the indices of height and width to obtain a basis of comparison with similar indices taken from skulls.

This subtraction of a figure of from 1 to 2 should also be carried out in order to group the heads into the recognised classes of long, medium, and short, as applied to the skull, but as the measurements in this paper refer entirely to the living subject I have thought it inadvisable to introduce any arbitrary, and not always accurate, deduction from the indices, and have compared tribe with tribe on the basis of measurements and indices which include the soft tissues.

The gnathic index used throughout is obtained by comparing the auriculo-alveolar with the auriculo-upper-nasal length.

Nelson Annandale has shown that the measurement from the ear-hole by a proper instrument, such as that of Prof. Cunningham (the one, I believe, used by Dr. Pirrie), give results which are very similar to measurements to the same points (nasion and alveolar point) from the basion, allowing for the soft tissues which cover the root of the nose and the alveolar margin of the jaw.

Fertits

Fertits

Measurements were made at Barboi (Table I.), and also at Renk and Melut (Table VII.). In the former case nine individuals were measured, and in the latter case only five, and a certain amount of discrepancy exists in the averages in the two cases. The stature was very much the same in both, 171 and 170 cm.; but the cephalic index in the first case was only 73·8 and all the individuals came very near this figure, while in the other case the index was as high as 78, and in this case also three out of the five had indices of nearly 80 or over. As might be expected, the vertical index in the first case is also low, 69·5, and in the second case, 71·2. Among the individuals of whom we have complete measurements (at Renk and Melut), the mesaticephalic individuals, the thigh and leg together measured 85 cm., or practically one half the height.

FIG. 111.—Native Pipe, Shilluk Tribe

FIG. 112.—Burun Woman

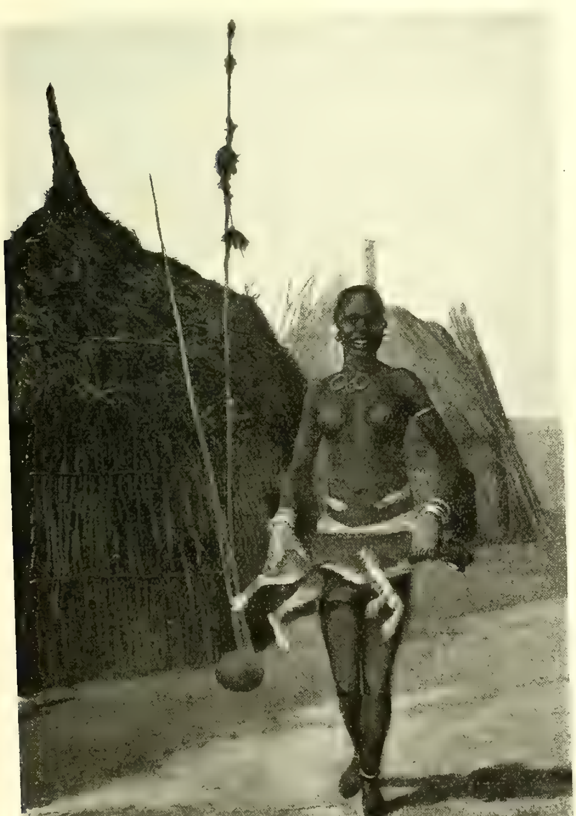


FIG. 113.—Burun Woman

FIG. 114.—Shilluk

SUDANESE TYPES

TABLE I.—FERTIT TRIBE (AT BARBOI)

Head and Face Measurements—											Average
Glabello-occipital length ...	197	196	191	187	190	196	196	190	202	—	—
Maximum breadth	150	144	138	141	140	142	142	142	150	—	—
Cephalic Index	*76·1*	*73·5*	*72·3*	*75·4*	*73·7*	*72·4*	*72·4*	*74·7*	*74·3*	—	*73·8*
Auriculo-vertical height... ...	142	135	130	130	131	133	133	134	145	—	—
Vertical Index	*72·1*	*68·9*	*68·1*	*69·5*	*68·9*	*67·9*	*67·9*	*70·5*	*71·8*	—	*69·5*
Total face length	112	120	110	112	118	118	114	120	124	—	—
Max. interzygomatic breadth ...	144	142	132	140	141	137	137	132	142	—	—
Facial Index	*80*	*84*	*83*	*80*	*83*	*86*	*83*	*90*	*87*	—	*84*
Span of arms	1800	1730	1750	1770	1800	1770	1800	1700	1800	1800	1768·5
Height	1770	1700	1690	1720	1660	1730	1740	1650	1740	—	1718

Furs

Furs

The Furs, inhabiting the region of Darfur, on the Western side of the Nile, constitute a large and important Sudanese tribe. Fifteen individuals were measured at Renk.

In stature they are considerably smaller than the Dinkas—168·3 cm., as against 180·2 cm.—but in other respects they resemble them closely.

They show distinct dolichocephaly of the head, a similar degree of prognathism, and nasal characters which are alike.

The lower limb—leg and thigh—measure rather less than one half of the total stature, and therefore are slightly shorter relatively than in the Dinkas.

Furawis

Furawis

Measurements of four individuals of this tribe were made at Melut, at Renk, and at Khartoum, and the condition of the hair is noted as being nil, or short, crisp and curly. In stature they are not very tall, the average being 171·7 cm., and the lower limb measures, on an average, 89·5 cm. In regard to the head the average length was 199 mm., and the cephalic index was 75, varying from 70 to 77, while the vertical index was 67·2, the alveolar was 107, and the nasal index, on the average, 102, indicating a very wide nose, but, at the same time, the nasal depth is considerable, 20 mm., which is larger than the average obtained from any other tribe. Summing up their physical characteristics we find them to be of medium height, with long legs and a trunk which is wide at the shoulders, with a broad but fairly prominent nose, a wide face, and a head tending to be rather round than long.

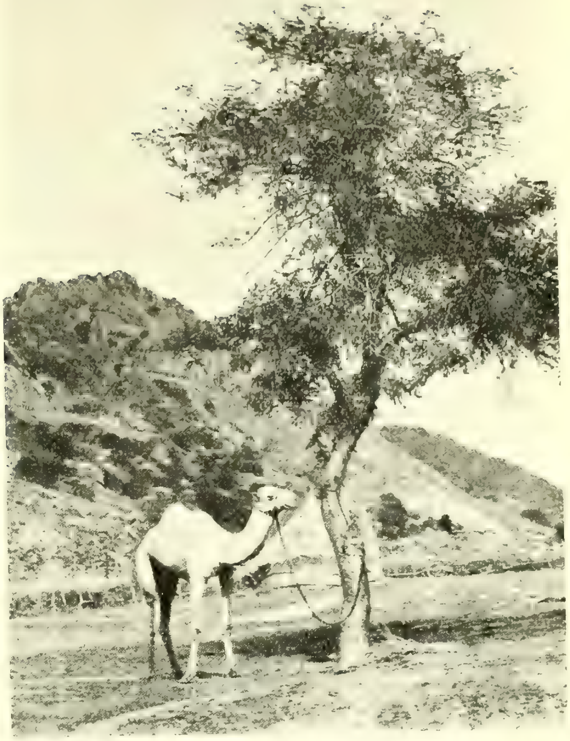
Gebelawis

Gebelawis

Altogether nineteen individuals of this tribe were measured, ten of them at Barboi and nine at Renk and Melut. The principal measurements show great similarity among the individuals measured at these two centres. For instance, the stature in one case is, on the average, 172 cm., in the other, 169, the span 178 and 177, the head length 192 and 190, and the cephalic index, on the average, 76·3 in both cases, the vertical index 68 and 72·1. The only diameters which show variations are the length and width of the face, which in one case gave an index of 89, and in the other of 79. The hair was nil, or short, thick, and curly, and the teeth were usually complete and perfect. Summarising the physical characters, we find them to be a tribe of medium height, considerably shorter than the Dinkas or even the Buruns, with head index which tends to be mesocephalic, again contrasting with the Dinkas, and contrasting also with the Nuers, and with a trunk which is rather long.

C. M. Wenyon

Fig. 115. Greek Trader at Bor with elephant tusks

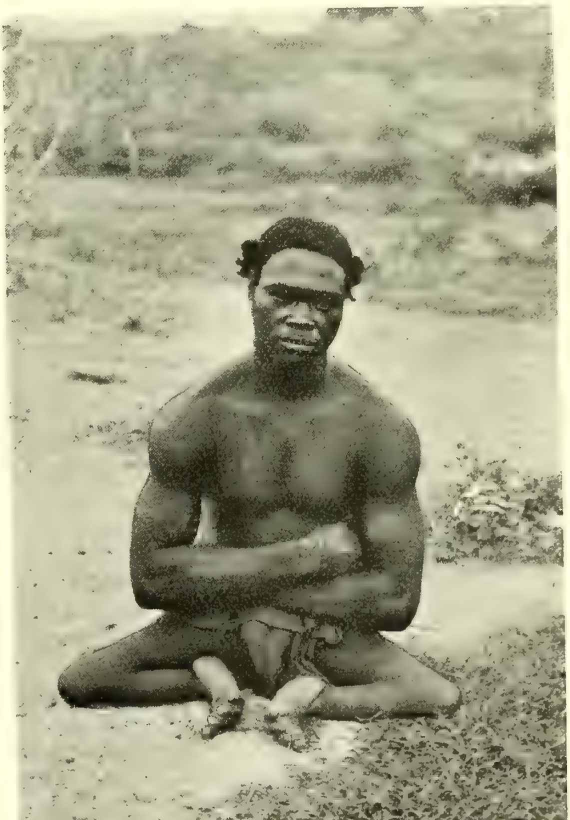


MacTier Pirrie

Fig. 116. View near Keili in the Gebel Country

C. M. Wenyon

Fig. 117.—Shilluks. Note position of leg



C. M. Wenyon

Fig. 118.—Native at Wau. Deformity resulting from infantile paralysis or congenital tabes

The nasal characters are not distinctive, and the facial index indicates a similarity of proportion to that found in several other tribes, and which shows that, in certain regions, the face inclines to be long and narrow, rather than broad.

TABLE II.—GEBELAWI TRIBE, AT BARBOI

											Average
Glabello-occipital length ...	194	180	190	196	180	195	190	190	192	192	190
Maximum breadth	143	140	145	154	150	157	153	154	158	150	145
Cephalic Index	*73·7*	*77·8*	*76·3*	*78·6*	*83·3*	*80·5*	*80·5*	*81·1*	*82·3*	*71·8*	*76·3*
Auriculo-vertical height... ...	140	134	140	137	137	141	127	139	133	141	137
Vertical Index	*72·2*	*74·4*	*73·7*	*69·9*	*76·1*	*72·3*	*66·8*	*73·2*	*69·3*	*73·4*	*72·1*
Total face length	121	110	104	120	102	115	102	117	108	111	—
Max. interzygomatic breadth ...	140	142	137	141	130	151	144	142	140	140	—
Facial Index	*86*	*77*	*76*	*85*	*78*	*76*	*70*	*82*	*78*	*79*	*79*
Span of arms	1770	1760	1790	1880	1600	1860	1700	1800	1750	1870	1778
Stature	1750	1710	1710	1800	1590	1710	1680	1790	1670	1750	1694

Nubas

Nubas

Thirteen individuals were measured, and all the measurements were obtained at Renk. The hair is short, crisp and frizzy, or curly, and, in some cases, nil. In stature the average is only 169·4 cm., resembling in this respect the Bongos and the Furs. The thigh and leg together measured 84 cm., or almost exactly one half of the total height, while the arm and forearm measured 62 cm. The cephalic index is, on the average, practically 76, and they show a general tendency to mesocephaly, while the vertical index was almost 70, and the skull, therefore, possesses considerable height. The alveolar index was 108, and the nasal index 100—that is, the width of the nose is, on the average, the same as the length. The forehead is, on the whole, retreating, and the head almost comes to a peak above the lambdoidal region. The photographs (Figs. 155, 156, 159, 160, 161, and 162) show the characters of the head and face, both in front view and profile.

The face is characteristically negroid, heavy in type, long rather than wide, and the cranium slopes down from the middle line sharply on either side, producing a dome-shaped appearance, which is in keeping with the high vertical index.

Bongos, or Dohr

Bongos

The present country of the Bongos lies between lat. 6° and 8° N. on the south-western boundary of the depression of the Bahr-El-Ghazal Basin. "In the extent of its area the land covers about the same surface as Belgium, but it is a deserted wilderness, averaging only about eleven or twelve people to the square mile. On the north it is only divided by a small country from that of the Dinka, which, however, it directly joins upon the north-east; the eastern branch of the extensive Nyam-nyam lands joins the Bongo at the south."[1]

Measurements were made of seven individuals at Renk and Melut, and the hair was found to be short, sparse and straight, the teeth usually complete and perfect. In stature they measured 169·2 cm., the lower limb measuring 85 cm., and more than half the total stature. The upper arm and forearm together measured, on an average, 61·4 cm., and the width of the trunk at the shoulders was 118 mm. The average length of the head was only 188 mm., and the cephalic index 76·7. The vertical index was 72·1, and there is, therefore, a distinct tendency to mesaticephaly among all the individuals. The facial index was 95, a figure which is only rivalled by that found in the Furawis.

[1] Schweinfurth, "The Heart of Africa."

Fig. 119. Small Ambatch Canoe. Shilluk with Spears

Fig. 120.—The same Shilluk as in Fig. 119 before embarking

Fig. 121.—Shilluks in Dug-cut on the Sobat

Fig. 122.—Ambatch Canoe on White Nile

This people appeared to be devoted almost exclusively to agriculture, and were of a docile and yielding disposition, unlike the Dinkas, and a large number of them had been reduced to slavery by the invading Khartoumers. By the Dinkas they were known as the Dohr. In complexion they are much less dark, or black, than the Dinkas, and in colour they are similar to the red-brown soil upon which they reside. "The jet-black Shilluks, Nuers, and Dinkas, natives of the dark alluvial flats, stand out in marked distinction to the dwellers upon the iron-red rocks, who, notwithstanding their diversity in dialect, in habit, or in mode of life, present the characteristics of a connected whole." In this series must be included the Nyam-nyams. Schweinfurth further states that the Bongos "rarely exceed a medium height, and that their prominent characteristics appear to him to consist in a more compact form of limb, a sharper development of muscle, a wider formation of the skull, and, generally, a preponderating mass in the upper part of the Bongo." Among the natives themselves this character of brachycephaly is recognised, and the native explanation is that the Bongo women as soon as an infant is born press its head downwards, but the Dinka mothers, on the contrary, press the heads of their babies from the side.

They appear to be distinguished by considerable skill in working iron, which is found in great quantities in the country in which they live.

The measurements which were obtained, it must be noticed, show that among the Nyam-nyams the head tends to be even wider than among the Bongos, and this width is shared by the face, the Bongo face being considerably narrower in proportion to its length than the Nyam-nyam average. In stature, too, the Nyam-nyams appear to be slightly taller.

In the Bongos then, as among the Nyam-nyams, there can be traced a distinct racial element, differentiating the tribes which show them from those adjacent to them.

The characters are—mesocephaly, with moderate stature, rather shorter lower limbs, the leg and thigh being nearly of equal length, and colour less dark than reddish brown in hue.

Nyam-nyams

Nyam-nyams

Of this savage tribe, travellers are agreed that it presents characters by which it can be identified at a glance amidst the whole series of African races. This physical identity is accompanied by features of customs and dress which give them additional interest. The greater part of their territory lies between the fourth and sixth parallels of latitude N., while westwards they extend for about five or six degrees of longitude, or an area of 48,000 square miles. The population is estimated at about two millions.

Of this tribe, ten individuals were measured at Renk and at Khartoum. Among these people the hair is short, thick, and curly, or may be nil. The stature was, on the average, 172·4 cm., while the thigh and leg together measured 85·4 cm., slightly less than half the stature. The arm and forearm measured 61·4 cm. The cephalic index was as high as 79, on the average, indicating a high degree of mesocephaly which was only equalled by the figure found among the Buruns, and the vertical index was 70·7, indicating a well elevated vault for the skull. The degree of prognathism was considerable, but not more than is found among several other tribes, and the facial index was 90.

The photographs (Figs. 165, 166, 190 and 191) show the characteristically shaped head, inclining to roundness, a wide and rather short face, distinct plumpness, producing roundness of contour, and a growth of beard.

C. M. WENYON

FIG. 123.—SHILLUK FAMILY AT BARBOI. Note woman smoking

A. MACTIER PIRRIE

FIG. 124.—DINKAS ON THE WHITE NILE, SHOWING STORK-LIKE ATTITUDE

Baris

Baris

These constitute another tribe of Nilotic negroes, of whom Schweinfurth states that, in their stature, they might rival the Patagonians. The measurements of four individuals are available, and they were obtained at Melut. Of this tribe, Baker[1] states that "the men are well grown—the negro type of thick lips and flat nose is wanting, the features are good, and the woolly hair alone denotes the trace of negro blood."

The hair was short, sparse, and curly, or, occasionally, entirely absent. The average stature was 174·1 cm., showing a height rather less than that of the Shilluks and considerably less than that of the Dinkas and some other tribes. Analysing the various parts, segments of the total height, the thigh and leg together measure, on an average, 89 cm., or rather more than half the length of the body, while the length of the upper arm and forearm was 64·4 cm. The head length was, on an average, 190, and the cephalic index was as high as 78·4. They are, therefore, distinctly mesaticephalic. The face also is fairly wide in comparison with its length. The nasal index was 95, while the amount of projection of the upper jaw, estimated by the gnathic index, was very considerable, although in this respect comparatively little variation was noticed among the whole of the tribes who were measured, the index varying from 106·6 in the case of the Nuers to 109, which is the index found among the Baris, and the same figure is also obtained on the average in the Fertits, the Buruns, and the Nyam-nyams. The teeth were complete and perfect in every case except one.

The Baris inhabit a wide stretch of country on either side of the Nile, south-west of the Dinka country, and with Gondokoro as a centre.

Sir Harry Johnston gives measurements of one individual, which, on the whole, tally well with these averages.

The nose is not usually so wide as Sir Harry Johnston's figures indicate, and is narrower relatively to its height than in several other tribes.

Dinkas

Dinkas

Ten individuals were measured at Deutemma, and a very complete set of figures was obtained (*see* Table III.) by measuring sixty individuals very completely at Barboi, Renk, Melut, Wantan, Kwatch, etc. A number of photographs also are appended showing characteristic features of this tribe.

The Dinkas are a very large tribe inhabiting the right bank of the Nile opposite to the Shilluks, and between these tribes there appears to be constant warfare. Of them Schweinfurth states that "individual tribes among them stand pre-eminent in the scale of the human race, but the majority of the western branch of this nation rarely exceeds a middle height." Of twenty-six representatives measured by him the average height was practically 5 ft. 9 in., while among the sixty individuals whose measurements are averaged here the stature was as much as 180·1 cm., *i.e.* 5 ft. 11 in. The Dinkas must be reckoned among the darkest of races, but the deep black of their complexion gives place to a manifest tint of brown when the ashes are washed off with which they delight in rubbing themselves. The hair of the Dinka is nearly always very meagre; it is generally closely shorn, except at the crown, where a tuft is left. The helmet-shaped combs of the Shilluks are never seen, but tufts of woolly locks are much in the fashion. The Dinkas live in a veritable iron age—that is to say, they live in an age in which iron is still of high value—but

[1] Baker, "Albert Nyanza."

FIG. 125.—YOUNG DINKA BEAU

their modes of manipulating this metal are not so highly developed as among some other tribes, and bows and arrows are unknown. In stature we find the average to be 179 or 180 cm. The averages of the individuals measured at different places show considerable similarity: the length of the head 198 or 195, and the cephalic index 71·2 and 72·8 respectively, in two different localities. There is no doubt, therefore, that the Dinkas are a tall people, with long narrow heads. The combined length of the thigh and leg is almost exactly one half of the height, and the hands are very long and narrow. The nasal index varies from 100 to 107, and the alveolar index is 107 in the average.

Scaphocephaly. In two cases among the Dinkas and in one case among the Nubas the head length was unusually great, the figures being 290 and 289 mm. in the former and 253 mm. in the latter.

This unusual measurement suggested that these were possibly cases of scaphocephaly, or deformity of the skull, associated with early closure of the sagittal suture, and characterised by growth in an antero-posterior direction, while the growth in width was impaired.

On examining the other measurements of the head, it became clear that in the second case among the Dinkas the other measurements were similar to the average obtained in other specimens of heads and no corroborative evidence of cranial deformity was afforded. I have therefore put this case on one side as probably an error in recording.

In the other case, however, the transverse measurements of the head were somewhat diminished, and I am therefore inclined to regard it as possibly a case of scaphocephaly, a condition which is known to occur with unusual frequency among Egyptian crania.

The Nuba case had been more completely measured and showed clearer evidence, especially in the great auriculo-ophryal and auriculo-frontal as well as in the auriculo-occipital lengths, combined with narrow width, that the case was clearly one of scaphocephaly. It is particularly interesting to have this record—which I believe is the first found in the living head among the tribes of this part of Africa—of a condition which occurs with unusual frequency in Upper Egypt.

In dealing with a large number of measurements it is often instructive to determine not only the average condition, but also the range of variation and the frequency of occurrence of the average. Among a series of Dinka heads examined in this way, the maximum length was 209 mm., the minimum 190, and the average 195—the usual length varying from 192–198.

The width similarly varied from 133 as a minimum to 150 as a maximum, the average being 142.

The cephalic index ranged from 66·7 to 76, but in the great majority lay between 70 and 74·9. The index of head height is on the average 69, and seldom lies outside the range of 68–72.

The nasal characters in a large series also require similar investigation, and in such a series the height ranges from 38–45 mm., being over 40 mm. in nearly every case, while the range of nasal length was very similar, viz. 38-44.

Among the Dinkas the nasal breadth is very considerable. In some cases it exceeded the length, and, in conjunction with this, one must remark upon the great width of the nostrils, which measured as much as 17 and 18 mm. respectively in two cases.

Limbs. The length of the forearm is always less than that of the upper arm.

The photographs bring out the nasal features, and the deformity of the teeth, which is so often practised among the Nilotic negroes, in the extraction, or in some cases the filing, of the central incisor teeth.

S. C. Dunn

Fig. 126.—Dinka Traders in Burun Country

[illegible]

Fig. 127.—Dinka Smelter

TABLE III.—DINKA TRIBE (AT DEUTEMMA)

											Aver-age
HEAD AND FACE MEASUREMENTS—											
Glabello-occip. length	200	196	200	196	204	200	203	195	198	190	—
Maximum breadth	136	149	150	144	145	136	149	137	140	133	—
Cephalic Index	*68*	*76*	*75*	*73·5*	*66·7*	*68*	*73·4*	*70·3*	*70·7*	*70*	*71·2*
Auriculo-vertical height... ...	137	136	143	140	135	127	133	140	135	134	—
Vertical Index	*68·5*	*69·4*	*71·5*	*71·4*	*66·2*	*63·5*	*65·5*	*71·8*	*68·2*	*70·5*	*68·6*
Minimum frontal diam.... ...	115	128	130	125	139	116	137	112	125	115	-
Auriculo-alveolar	106	106	94	104	104	109	98	104	105	110	—
Upper face length	60	64	56	64	61	67	57	74	65	64	-
Total face length...	117	114	106	114	105	118	112	124	120	115	—
Max. interzygomatic breadth ...	121	137	133	141	149	133	142	132	132	122	
Max. intermalar breadth ...	120	135	124	130	136	122	124	124	114	117	—
Facial Index	*96*	*98*	*93*	*92*	*91*	*91*	*87*	*94*	*86*	*96*	*92·2*
Ext. orbital breadth	116	115	111	116	118	116	111	110	113	106	—
Internal ocular breadth	37	34	33	40	32	40	34	37	34	33	-
Bi-auricular diameter	111	112	111	111	124	106	120	110	115	108	—
NASAL MEASUREMENTS—											
Nasal height	38	43	43	45	41	44	42	—	—	—	-
Nasal depth	18	16	16	17	17	19	18	—	—	—	—
Nasal length	41	44	42	44	40	44	38	—	-	—	—
Nasal breadth	40	46	44	42	42	39	44	—	—	—	—
Nostril length	10	13	10	11	12	14	11	—	—	—	—
Nostril breadth	17	15	14	15	14	18	15	—	—	—	—
Nasal Index	*105*	*107*	*102*	*93*	*102*	*88*	*105*	—	—	—	*100·1*
LIMBS—											
Upper arm length	330	315	325	385	345	330	330	—	—	—	—
Forearm length	315	300	310	330	320	295	315	—	—	—	—
Thigh length	480	460	445	480	485	485	500	—	—	—	—
Leg length	465	440	425	470	480	465	485	—	—	- -	—
Span of arms	1950	1860	1980	1960	1960	1800	1900	—	-	—	1915
Stature	1800	1770	1750	1800	1850	1710	1850	—	—	—	1790
Condition of hair, usually nil, in some cases long and silky, in some frizzy											

NUERS

Nuers

This tribe is found some three days' journey south of the Burun tribe. (*See page* 352.)

Measurements of a number of male representatives were taken at Dwo and Barboi, and at Renk. In the former case twenty-seven individuals were measured (Table IV.), and in the latter thirteen (Table VII.), but in the first case the measurements were not so complete as in the second.

Taking those that were measured completely (Table VII.). Among these people the head length varied from 181–203 mm., while in the first set the figures were from 180–200 mm. In the majority of cases the measurement lay between 190 and 200 mm. The maximum breadth of the head ranged from 130–148 mm., and from 135–148 mm. in the two sets combined, the average measurement being practically 141 mm. The cephalic index on the average was 73, ranging from 70–78, or even 79 in one case, but the great majority were between 70 and 75, and, therefore, the tribe is on the whole dolichocephalic. The cranial height, as ascertained by taking the auriculo-vertical height, varied from 127–145 mm. in the one set (Table VII.), and from 132–138 in the second (Table IV.). The average vertical index in Table IV. is 69, and in Table VII. 70.

Turning next to the facial index, which is estimated from the proportion of total face length to the intermalar breadth, figures are available from among the individuals represented in Table VII., and in them the average facial index is 91.

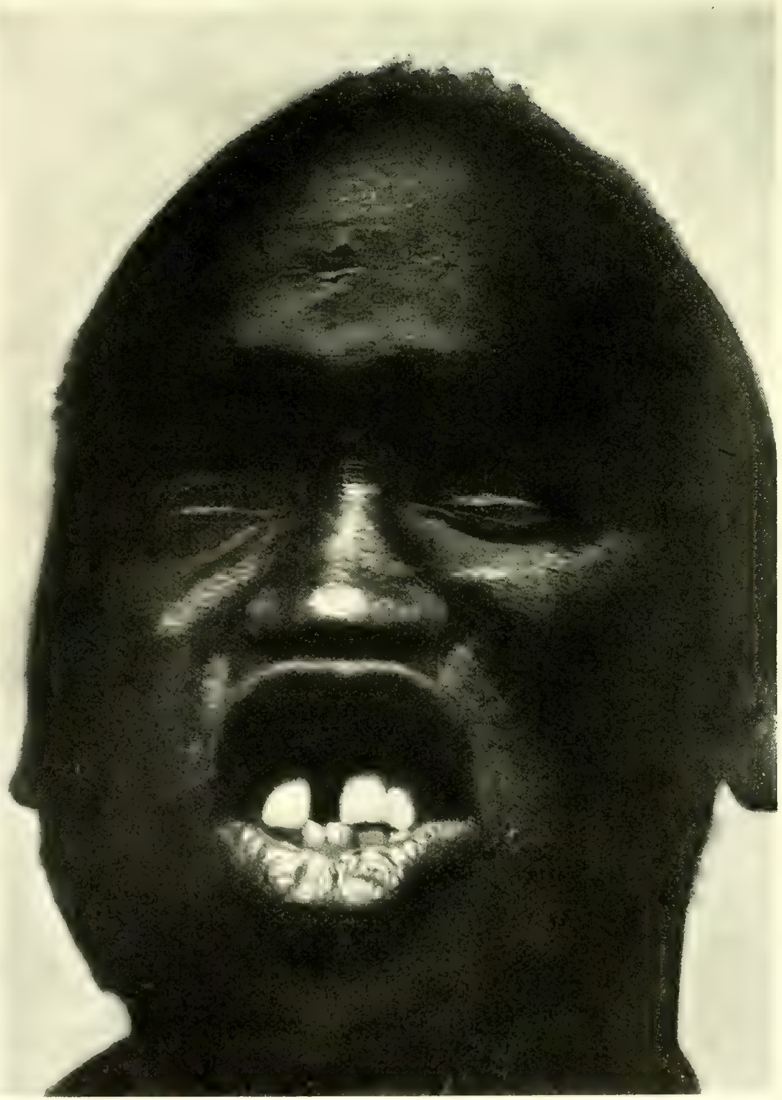


Fig. 128.—Dinka from Bahr-El-Ghazal

Fig. 129. Characteristic Nose and Teeth of a Dinka

The degree of prognathism among different tribes constitutes an important factor in discriminating between the races, and an attempt has been made to obtain an index for this feature by comparing the length of a radius drawn from the auricular point to the root of the nose with one drawn from the auricular point to the alveolar point on the gum at the root of the upper incisor teeth. An index of this kind affords a rough method of estimating the amount of projection of the upper jaw. In the great majority of cases among the Nuers this index was from 100 to 110, or even, in one case, 115 mm. In only one individual had it sunk as low as to 92·8, and the average among the thirteen individuals was 106·6. In an aboriginal Australian, measured by Prof. Cunningham,[1] the alveolar index, measured in the same way, was 104 mm.

Characters of the Nose. The nasal height showed considerable variation. Among the one set of representatives the height varied from 32 to 50 mm., while in the other the figures varied from 37 to 47 mm. Comparing this with the breadth of the nose we find the diameter, as might be expected, to be large, being as much as 47 mm. in one case among the first set, and 45 mm. in the second. In many cases the breadth exceeded the length and the height. The average nasal index was found to be 103 in the first set, and 97 in the second.

Limbs. The length of the upper arm varied from 305 to 385 mm. in one set of people, while in the second set it was from 330 to 370 mm., and the average length was 348 mm. In one case the length of the forearm exceeded that of the upper arm by 5 mm., but the average length of the upper arm among the first set was 339 mm. and that of the forearm 313 mm., while in the second set the corresponding figures were 348 and 311 mm. The upper arm, therefore, practically always exceeded the forearm in length.

Measurements of the length and breadth of the hand and fingers were made in some cases, with the result that the average maximum length of the fingers was 104 mm. and the breadth of the hand in the same cases was 79·4 mm.

Turning to the lower limb, the length of the thigh varied from 450 to 540 mm. in one set, and from 430 to 465 mm. in the second, the average length being 452·8 mm., while the leg varied from 390 mm., which is unusually short, and 440 mm., which is about the average, to a maximum of 518 mm. among the first set measured. But the variation in length among the second set was much less, from 425 to 460 mm., and the average length was 444·2 mm. The length of the foot was, on the average, 241 mm. to the tip of the second toe, and 248 mm. to the tip of the great toe, while the breadth of the foot was, on the average, 99 mm.

The value of these and the numerous other measurements as racial characters will be best discussed by carrying out a comparison between the results obtained in them and those found in the other tribes.

The stature, among the first set of people, ranged from 1650 mm. to 1760 mm., and was even as much as 1950 mm. in one individual, but the average stature was 1780 mm. The average obtained in the second case was 1795·7 mm. The two sets of people, therefore, show a close resemblance to one another, with a few minor variations.

Summarising the general physical characters of this tribe it is found that they are a tall people. The length of the lower limb is not quite half the length of the body, but the span of the arms usually exceeds the height by 100 mm. The length of two segments of the lower limb exceeds that of the corresponding parts of the upper limb by 237 mm., while, as regards their head and face, they are dolichocephalic, with vertical height which is even less than the width of the skull. The face is rather wide and the zygomatic arch is fairly prominent. The minimum frontal diameter is rather high, and the nasal index is high and resembles that found among such races as the native Australian.

[1] Cunningham, D. J., "The Head of an Aboriginal Australian." *Report of the Royal Anthropological Institute*, 1908.

A. MacTier Pirrie

FIG. 130. SHILLUK. Note the head-dress of felted hair

A. MacTier Pirrie

FIG. 131. BURUN

A. MacTier Pirrie

FIG. 132.—DINKA

A. MacTier Pirrie

FIG. 133.—BURUN WARRIORS

TABLE IV.—NUER TRIBE (AT DWO AND BARBOI)

																												Average
HEAD AND FACE MEASUREMENTS—																												
Glabello-occipital length ...	180	198	187	190	193	200	200	192	192	190	195	200	193	180	194	190	192	192	198	190	200	200	200	200	194	192	200	—
Maximum breadth	142	140	144	145	142	143	143	135	137	143	140	140	145	140	148	145	146	148	140	135	142	140	150	150	144	143	144	—
Cephalic Index	*78·9*	*70·7*	*77*	*76·3*	*73·6*	*71·3*	*71·5*	*70·3*	*71·4*	*75·3*	*71·3*	*70*	*75·1*	*77·8*	*76·3*	*76·3*	*76*	*77·1*	*70·7*	*71·1*	*71*	*70*	*75*	*75*	*74·2*	*74·3*	*72*	*73*
Auriculo-vertical height ...	127	133	130	135	131	—	135	137	130	132	135	135	130	125	128	130	136	128	134	135	143	145	135	137	133	131	133	—
Vertical Index	*70·6*	*67·2*	*69·5*	*71·1*	*67·9*	—	*67·5*	*71·4*	*67·7*	*68·8*	*69·2*	*70*	*67·4*	*69·4*	*66*	*68·4*	*70·8*	*66·7*	*67·7*	*71·1*	*71·5*	*72·5*	*67·5*	*68·5*	*68·6*	*68·2*	*66·5*	*69*
Max. intermalar breadth ...	122	102	128	125	120	130	140	117	122	130	123	110	120	120	135	132	122	132	122	115	108	105	140	142	122	120	142	—
Bi-auricular width	113	110	113	115	113	116	133	110	110	109	105	105	115	115	105	110	115	103	104	110	110	115	113	114	118	120	130	—
Auriculo-alveolar length ..	110	105	110	110	106	105	105	100	103	111	95	100	105	110	108	110	106	105	93	100	110	108	100	104	108	110	105	105
Auriculo-upper nasal length	100	94	100	100	—	96	95	92	97	95	90	92	—	100	98	97	98	98	90	90	93	100	97	100	100	100	95	97
NASAL MEASUREMENTS—																												
Nasal height	40	35	40	40	40	40	42	42	45	40	32	32	45	42	44	42	47	43	32	40	40	42	37	36	47	50	40	—
Nasal depth	19	17	18	18	17	18	18	17	19	20	18	17	19	19	18	20	19	18	14	16	19	18	18	17	17	15	18	—
Nasal length	42	37	39	38	41	42	40	40	47	43	37	35	49	42	45	45	49	47	34	40	44	44	40	37	52	54	40	—
Nasal breadth	43	40	41	41	44	38	44	37	36	47	42	40	44	44	42	45	42	40	39	35	42	40	40	40	43	44	42	—
Nasal Index	*107*	*114*	*102*	*102*	*110*	*95*	*104*	*88*	*80*	*117*	*131*	*125*	*97*	*104*	*95*	*107*	*89*	*93*	*121*	*87*	*105*	*95*	*108*	*112*	*91*	*88*	*105*	*103*
Nostril length	10	8	11	11	9	10	12	10	11	11	11	10	11	12	11	10	11	11	5	10	11	11	10	8	10	10	11	—
Nostril breadth	13	14	14	14	14	15	16	14	14	14	13	14	15	15	14	13	15	14	11	14	16	15	14	14	14	15	15	—
LIMBS—																												
Upper arm length	315	320	345	340	305	335	375	355	345	335	320	320	325	315	350	330	320	350	320	355	325	320	350	355	380	385	385	—
Forearm length	300	295	330	325	310	300	325	325	305	300	295	295	310	300	325	303	310	325	300	320	300	295	320	325	350	355	325	—
Thigh length...	450	460	475	480	450	455	525	525	485	490	480	460	485	450	517	487	485	515	485	520	460	460	480	490	540	540	535	—
Leg length	390	440	460	460	440	440	505	490	450	470	455	440	445	395	465	465	445	460	450	485	400	400	465	450	495	490	518	—
Span of arms	1980	1870	1960	2000	1820	1830	2000	1920	1850	1980	1930	1820	1830	2000	1920	1940	1890	—	1800	1930	1740	1730	1900	1860	2000	2030	2030	—
Stature	1870	1760	1870	1870	1760	1800	1906	1800	1750	1860	1800	1690	1700	1920	1800	1820	1760	—	1760	1880	1650	1650	1820	1820	1900	1950	1920	1780

Condition of hair—in practically every case "free and flowing" or "long and wavy"

C. M. Wenyon

Fig. 134.—Natives near Bor

White appearance of some due to the smearing of bodies with wood ash from the cattle shed in the rear. This is possibly done as a protection against mosquito bites

C. M. Wenyon

Fig. 135.--Shilluks at Taufikia

Shilluks

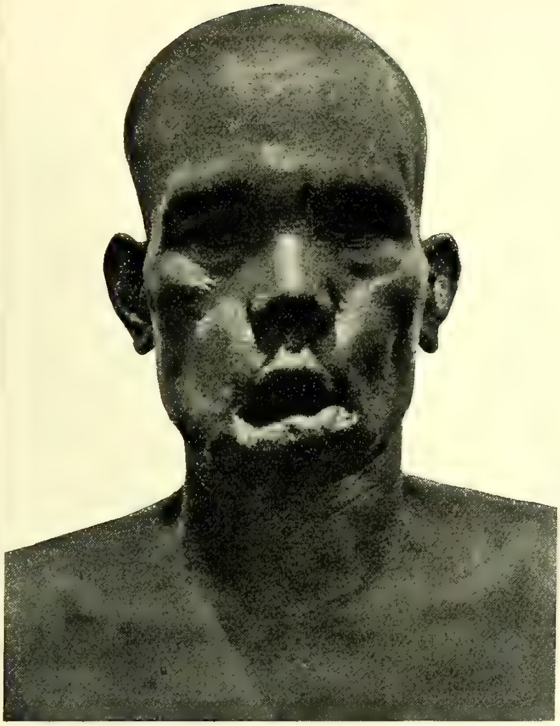
This tribe constitutes one of the largest of the Nilotic negroid peoples, and they are considered to possess affinities with the Dinkas, the Bongos, and the Baris. In Schweinfurth's account of this tribe[1] he states that "they inhabit the entire left bank of the White Nile, occupying a territory about 200 miles long and about 10 miles wide, which extends right to the mouth of the Gazelle River. Hemmed in by the Baggara on the west, they are prevented by the river from extending farther eastwards, and only the lower course of the Sobat has any of the Shilluks for its denizens. Their subjection to Egyptian government, which was completed in 1871, has caused a census to be taken of all the villages on the left bank of the Nile, which resulted in an estimate of about 3000. Taking the character of the villages into account, this would give a total of above a million souls for this portion of the Shilluks alone. Now, the Shilluk land, which lies upon the White Nile, has an extent of hardly less than 2000 square miles, and, when the number of heads upon this is compared with those in the populous districts of Europe, we are justified in reckoning from 600 to 625 to a square mile; a result altogether similar is arrived at from reckoning based on the estimate of there being 3000 villages, each village having huts varying in number from 45 to 200, and each hut averaging four or five occupants: this would give a total of about 1,200,000. This, in fact, is an estimate corresponding entirely with what the Mudir of Fashoda, who was conversant with the details of all state affairs, had already communicated to me in 1869. . . . In the Shilluk territory there are probably no less than 600 residents to the square mile, whilst in Bongo land, within 180 miles to the south-west, there would be found hardly a dozen occupants on an equal area. Most of the negro tribes are distinguished by the form of their huts. The huts of the Shilluks are built with higher roofs than those of the Dinkas, and as a rule are of smaller circumference. The conical roofs do not rise to a peak, but are rather in the shape of flattened domes, and in this way they acquire a singular resemblance to mushrooms. (Fig. 57.) The external appearance of the Shilluks is by no means agreeable, but rather offensive to the beholder. Their physiognomy hardly offers that decided negro type which their swarthy complexion would lead one to expect, but, judged by the shape of the skull, this people belong to a less degraded race of Central Africa, distinguished from other negro stock by a smaller breadth of jaw and by a less decided narrowness of head. The stature of the Shilluks is very moderate, and, as a general rule, is short compared with that of the lank and long-legged Dinka inhabitants."

There is great variety in the way in which the hair is dressed. In some cases, however, the hair is closely cropped. Their arms are long spiked lances, and bows and arrows are unknown among them, as amongst the neighbouring Dinkas, whilst, on the contrary, amongst the Nuers they are the chief weapons.

In many cases the teeth are deformed, though this fact was not noticed among the individuals who were measured by Dr. Pirrie. The measurements were made mostly at Melut, and two individuals whose measurements are included were examined at Taufikia.

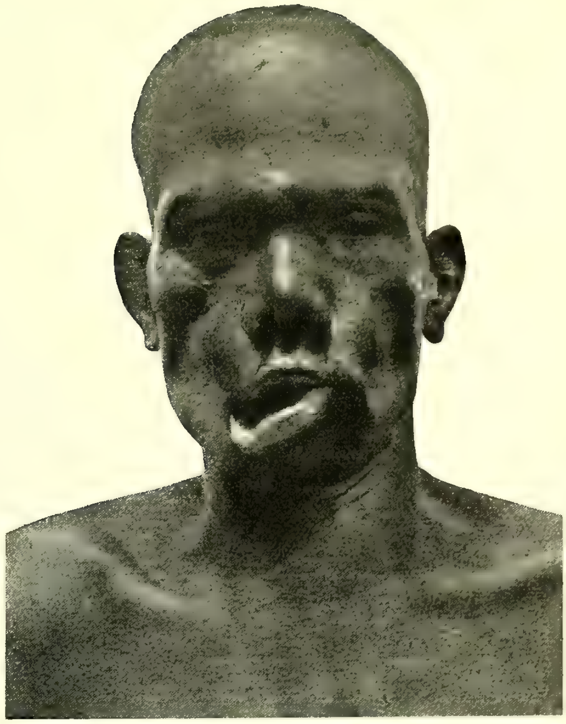
Stature, etc. The average stature of those who were measured was 176·7 cm. The average length of the head was 196 mm., and the average width was 140 mm. The cephalic index was, therefore, 71·4, and they show a distinct tendency to dolichocephaly. The face is wide, the index obtained by comparing the length with the width being as much as 92 on the average. Several characteristic photographs showing the general build in this tribe are appended.

[1] Schweinfurth, "The Heart of Africa."



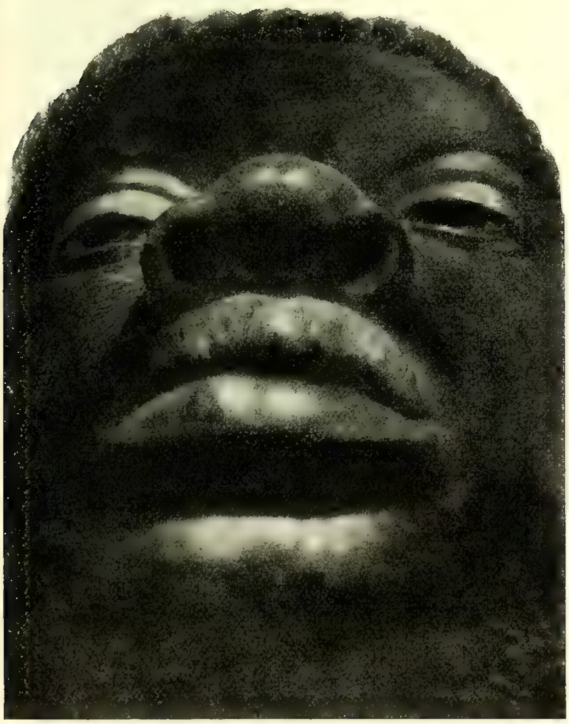
A. MacTier Pirrie

Fig. 136.—Bilateral facial paralysis in a Burun, at Atalminar



A. MacTier Pirrie

Fig. 137.—Same case, "to show manner of supporting lower lip"[1]



A. MacTier Pirrie

Fig. 138.—Nostrils of a Dinka

A. MacTier Pirrie

Fig. 139.—Profile of leg, to show curvature of tibia in a Burun

The photographs (Figs. 111, 114, 117, 119, 120, 130, and 135) show them to be a fairly tall, long-legged people, with long hands and forearms, and the heads to be long and fairly high, with wide faces. They are lean, but muscular, and the head is either shaven, or the hair, when present, is ornamented in fantastic shapes. Ornaments are worn round the arms and neck, and the clothing is often nil, at least among the males.

The favourite weapon is the long slender-bladed spear. Their principal occupation is fishing, which is carried on in their light ambatch canoes. (Figs. 119–121.)

They adopt the peculiar stork-like attitude of resting one foot against the inner side of the opposite knee when standing, which is so widely found among Nilotic negroes. (Fig. 117.)

Their colour is jet black, but they smear their oiled bodies with white ash.

TABLE V.—SHILLUK TRIBE (AT MELUT, PRINCIPALLY)

											Average
Glabello-occipital length ...	194	197	190	198	195	200	190	201	210	192	196
Maximum breadth	144	145	135	135	145	144	140	144	144	128	140
Cephalic Index	*74·2*	*73·6*	*71·1*	*68·2*	*74·4*	*72*	*73·7*	*71·6*	*68·5*	*66·7*	*71·4*
Auriculo-vertical height... ...	141	137	133	134	128	132	138	135	143	133	135
Vertical Index	*72·7*	*69·5*	*70*	*67·7*	*65·6*	*66*	*72·6*	*67·2*	*68*	*69·3*	*68·9*
Total face length	–	110	—	120	106	118	116	120	105	120	—
Max. interzygomatic breadth ...	-	143	—	138	133	134	132	133	133	108	—
Facial Index	—	*76*	—	*87*	*75*	*88*	*88*	*90*	*79*	*112*	*92*
Span of arms	—	1800	1820	1850	1900	1880	201	1800	1850	1880	1828
Stature	—	1770	1760	1800	1750	1800	1880	1700	1760	1760	1767

BURUNS

This tribe, hitherto largely unknown, inhabits a tract of country on the western frontier of Abyssinia, eastwards from Melut, from latitude 11 N. to latitude 8·5 N.

TABLE VI.—BURUN TRIBE, AT SAHAHIR

HEAD AND FACE MEASUREMENTS—											Average
Glab.-occipital length ...	2020	198	190	190	197	198	192	201	183	197	204	–
Maximum width	157	150	135	150	150	154	148	147	141	150	152	—
Cephalic Index	*77·7*	*75·8*	*71·1*	*78·9*	*76·1*	*77·8*	*77·1*	*73·1*	*77·0*	*76·1*	*74·5*	*76*
Auriculo-vert. height ..	141	142	137	133	142	132	121	138	128	145	147	—
Vertical Index	*69·8*	*71·7*	*72·1*	*70·0*	*72·1*	*66·7*	*63·0*	*68·7*	*69·9*	*73·6*	*72·1*	*70*
Min. frontal	130	120	121	134	131	143	131	142	125	126	134	—
Bi-auricular diameter ...	—	104	102	116	115	120	112	120	115	114	117	—
Upper face length ...	68	74	62	56	68	67	62	70	56	67	74	—
Total face length ...	110	120	116	100	126	130	102	114	114	122	134	—
Max. interzyg. breadth ...	140	130	126	138	142	132	133	150	132	140	142	—
Max. intermalar breadth	128	125	123	130	127	141	130	135	126	130	136	—
Ext. orbital breadth ..	118	114	108	118	120	115	115	125	115	112	125	—
Internal ocular	34	36	35	36	40	37	37	41	31	38	38	—
Facial Index	*78*	*92*	*92*	*72*	*89*	*98*	*76*	*76*	*86*	*87*	*94*	*88*
NASAL MEASUREMENTS –												
Nasal height	45	47	44	42	47	52	44	48	47	44	48	—
Nasal depth	17	18	18	15	21	20	19	21	17	18	20	—
Nasal length	47	44	42	38	44	49	42	39	45	39	50	—
Nasal breadth	40	40	43	40	49	41	45	47	38	42	41	—
Nasal Index	*89*	*85*	*97*	*95*	*104*	*79*	*102*	*98*	*80*	*95*	*85*	*90*

A. MacTier Pirrie

Fig. 140.—Burun: Sitting Posture

TABLE VI.—BURUN TRIBE, AT SAHAHIR (*continued*)

												Average
Limbs—												
Upper arm length ...	310	330	330	315	340	335	330	340	—	330	350	—
Forearm length ...	295	320	310	295	320	320	315	330	—	295	320	—
Thigh length ...	430	485	470	460	470	500	475	510	—	510	510	—
Leg length ...	420	470	460	450	460	480	475	510	—	510	510	—
Span of arms ...	1800	1960	1900	1820	1940	1950	1940	2000	—	1940	2000	—
Stature ...	1700	1810	1800	1730	1800	1890	1800	1900	—	1900	1900	1820
Hair, usually nil.												

Notes on Customs, etc., of the Buruns and other tribes

The following notes were made by Dr. Pirrie and are reproduced verbatim:—

Habits and customs

"Unlike the river Negroids, who inhabit plains and marshes, the Buruns dwell in dense forests. Their physical appearances, habits and customs, and their weapons, are quite distinct from those of the river type, from whom they have undoubtedly descended. They live in small huts widely separated, have no cattle, use the bow and poisoned arrow, and also carry a throwing-stick which sometimes closely approaches the typical boomerang.

"Their dialect is closely related to that of the Nuers, but in their physical appearance they seem shorter and better built.

Salutation

"The form of salutation practised by these tribes varies considerably. One has heard of the habit, a somewhat objectionable one, among the Bahr-El-Ghazal tribes of spitting on the face of a friend as indicative of the strongest affection. The Nuer tribe is also addicted to this custom, and it requires the utmost tact to escape from such unpleasant attentions, without injuring their susceptibilities. Personal experience has taught me to be on the alert to anticipate the bestowal of the customary token of their good-will, and at the first sign of their intention to greet me thus I hold out my hand, which becomes the recipient of the salute. Among all well-educated Nuers, Dinkas, and Shilluks, however, the ordinary method of salutation is to hold the outstretched hand palm forwards, either over the head or above the level of the eyes, while at the same time repeating the word 'Ubaba.' According to Wilson, the greeting is 'Yubah Ba-wotich,' but the former is what one usually hears.

"The Burun has a different greeting. Before one comes into close proximity to a Burun he says in a distinct voice 'Mooka,' which means 'friend'; thereupon the word 'Mooka' is to be returned, and their peculiar hand-shake follows. This is effected by both parties mutually snapping the first and second fingers together against the thumb. Were it not the fact that the Burun smears himself with vegetable oil and war-paint, this form of greeting would be wholly unobjectionable; as it is, however, he invariably leaves an impression which the average white man is slow to appreciate.

"Another extraordinary form of greeting I occasionally found amongst the Buruns was the 'afoo' (in Arabic). This is possibly of Arab origin. It consists in making the third-finger knuckles crack over the head of the saluted. This is done in perfect silence as regards speech, and each walks away without saying a word. It is also practised upon the sick, and is supposed to afford them material relief.

Snake-magic

"The Dinkas, Shilluks, and Nuers have an interesting snake-magic. I am inclined to think that the Dinkas practise it most. It is rather snake-magic than snake-worship, though to a casual observer, imbued with the mystery which surrounds the subject, it would appear as though the Dinkas actually worship their snakes. The Dinka is remarkably

S. C. DUNN

FIG. 141.—BURUN WOMAN ANOINTING HER HUSBAND WITH OIL AND RED OCHRE PRIOR TO A JOURNEY

S. C. DUNN

FIG. 142.—BURUNS ON YABUS RIVER

reticent on the matter, a fact which is to be explained by reference to the uses to which snake-magic is put. If a Dinka has an enemy he may cause his snake, or one of the particular species with whose magic he is conversant, to inflict injury upon the enemy, or upon his family or cattle. If anyone has been bitten by a snake, or has had a narrow escape from a snake, or has merely seen a snake, or heard one rustling in the grass, he is sure to make enquiries as to the master of these snakes, for to his mind every snake has a master. Some snake-master, perhaps in another village, hears of this incident, and smiles grimly, whereupon men draw their conclusions.

"A snake-magician is considered wonderful, for he is so astute that he seldom or never gives himself away. If he is clever he can ward off the snakes of other magicians. They require, so they say, to keep a special cow for the snake, that it may never lack milk. If they have no cow they will set apart a goat for the same purpose, and if they have neither cow nor goat they are unable to practise snake-magic at all. Cows and goats set apart for this purpose are never given in exchange for wives and cattle.

Animal-magic

"Other animals besides the snake are used for the purpose of practising magic. The crocodile, the hyena, the jackal, and even the lion, are all utilised by the magician. The crocodile-magic is looked upon as one of the most potent forms. I came across an instance where magic had been practised for many years, to prevent the women and children being caught while going to the river for water. The greater part of this magic consisted in incantations, wearing peculiar charms, twisting and untwisting a small piece of string in a particular hut, and in leaving offerings of meat upon the river bank. The crocodile accepted the offerings, and respected the motives of those who made them.

"The Hamegs and Fungs, who live on mountains to the north of the Burun country, have many superstitions regarding hyenas, lions, and leopards. A hyena may come in the night, may tear you open and eat all your inside. He is not a real hyena, but your enemy in the shape of a hyena. So skilful is he that in the morning no wound is visible, the only result being that you experience a certain degree of indigestion. You curse your enemy in his hyena form.

Mythology

"One could speak at great length on the mythology of these various tribes. The river tribes have a god, who seems mostly to be a rain-god. By the Dinkas and Nuers he is called 'Deng-Dit'; by the Shilluks 'Nekang.' There are many interesting stories with regard to the origin of the tribe. They all have reference to 'Deng-Dit' or 'Nekang,' but over and above this rain-god they have another god, a universal creator, maker and ruler of the universe. Of him one seldom hears. One of his names is 'Jok,' and it is a curious feature in their beliefs that they take a very pessimistic view of their Creator. He brings the bad things in life as well as the good, and that weighs upon their minds much more than the benefits he confers. According to one writer, 'Jok' is referred to as the devil, but this is not correct. He is to be approached through the medium of the rain-god. The latter is a very real personality to them, but of the Supreme Being they have but a hazy idea."[1]

A large number of individuals was measured. The stature was, in two sets of figures, on an average 175–180 cm., the maximum stature being 195 and the minimum 164. In stature, therefore, they must be classified among the races of medium height.

The maximum head length was 211 and the minimum 172, while the average was 189·7.

[1] Further information on this interesting subject, and on the beliefs and customs of tribes in the Bahr-El-Ghazal, is given by Captain Lyle Cummins in the Parliamentary Blue Book on Egypt and the Sudan, 1906. (Enclosure 4 in No. 2, p. 97.)—A.B.

A. MacTier Pirrie

Fig. 143.—Burun Dance

S. C. Dunn

Fig. 144.—Burun Village

The cephalic index on the average was 76 in one set and 79 in another larger series, and the index of cranial height 70 and 71 respectively. This tribe, therefore, shows a tendency to round-headedness equal to that found among the Nyam-nyams, the cranial height index also being similar in these two tribes.

In stature this resemblance is also distinct, the averages being 175·9 cm. among the Buruns, and 172·4 cm. among the Nyam-nyams.

The limbs among the Buruns are of moderate length, the upper arm and forearm measuring 32·2 and 30 cm. respectively, figures which are almost identical with those found among the Nyam-nyams, where they are 32 and 29.

The face is not very wide, the index being 88 and 89 in the two sets of Buruns, comparing again with an average index of 90 among the Nyam-nyams. The gnathic index is 109, a figure similar again to that in the Nyam-nyams.

The characters of the nose are of interest, the nasal index being 90 and 96 in the two sets of Buruns, and among the Nyam-nyams 93.

The nose is, therefore, in these two tribes less wide and flat than among the adjacent Dinkas and Nuers.

Abyssinians

The measurements of four members of this race were taken, but in no case was a complete set obtained, and the information resulting is therefore small.

They tend to mesaticephaly, with good average height of skull, and the bi-auricular diameter, 113·5 mm., is less than among any of the other tribes examined.

Summary of General Physical Characters

Summary of physical characters

If one compare the figures obtained from measurements of the Nilotic tribes with those of the aboriginal inhabitants of other lands—*e.g.* the native Australian—some criteria appear which distinguish the Nilotic negroes from them, and may be considered as characteristic.

These characters of the tribes may be summed up as follows :—

The length of the head in all cases is of moderate size, varying from 188 to 195 mm., and thus is shorter than in the native Australian. In a few cases the length exceeds 200 mm. The width, however, is in all cases larger, varying from 142 mm. among the Dinkas to 150 or 151 mm. among the Buruns and Nyam-nyams, as against a width of 132 mm.

The cephalic index is, therefore, never very low, but ranges from 72·8, indicating a moderate degree of dolichocephaly, to 79, in which distinct mesaticephaly is present.

It must be admitted that this range of averages is not a wide one, and does not necessarily in itself indicate clearly varieties of race among the tribes.

The minimum frontal diameter is much longer than in the native Australian, varying from 119 mm. to 127 and 130 mm., while in the Australian it sinks to as small a figure as 91 mm.

The circumference of the head tends to be large, but this measurement is of little value for purposes of comparison.

Taking the auriculo-glabellar, auriculo-ophryal and maximum auriculo-frontal radii, it is evident that there is no great elevation in the region of the glabella, and that the frontal bone rises upwards with a degree of forward convexity and a slope which produces a well-shaped forehead, and this feature is uniform in all the tribes.

This fact contrasts remarkably with the Australian, in whom the first measurement is uniformly larger, and the latter (auriculo-frontal especially) is smaller than in any of the tribes described here.

S. C. Dunn

Fig. 145.—Buruns on the Yabus

S. C. Dunn

Fig. 146.—Buruns on the Yabus

The contour of the hinder part of the skull, however, does not show the same difference, and varies in the races; in some cases, *e.g.* in the Buruns and Nuers, it projects well backwards, while in others, *e.g.* Furs, it is less prominent. In the Furs and Fertits it is rather shorter than in the Australian (107 and 109 against 111), while in all the other tribes it is longer, reaching a maximum of 118 and 119 in the Nuers and Buruns respectively.

The face is longest among the Furawis—121 mm., and shortest among the Dinkas—111 mm., but among these latter and most of the other tribes it is similar in length to that of the Australian.

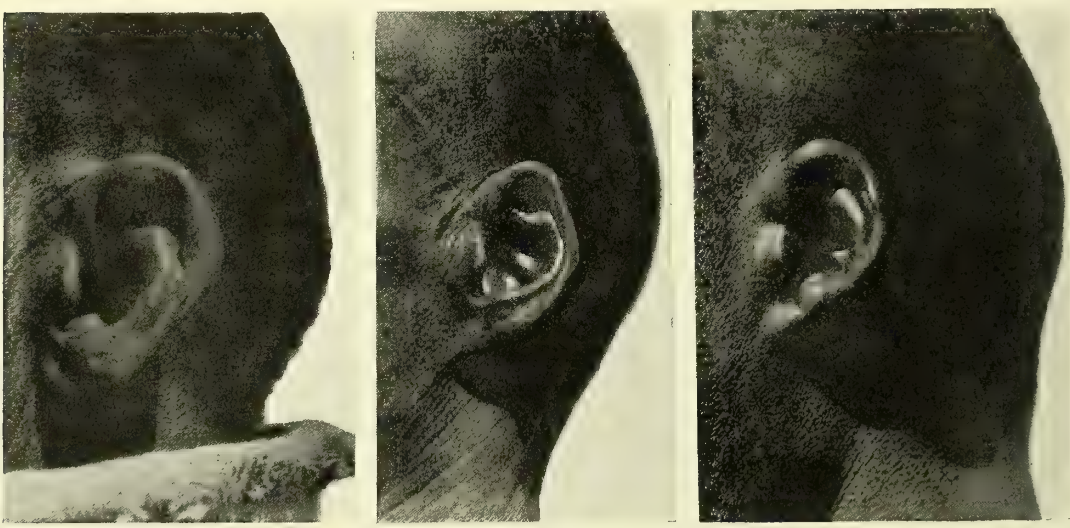
The face width (maximum intermalar width) is high in all, and the interzygomatic breadth is even greater, and particularly so among the Baris and Furawis.

The internal ocular width is practically the same in all the tribes, and varies only from 35–37 mm. The same constancy is found in the auriculo-alveolar measurement.

The nose is in all cases flattened and wide, and projects forwards much less than in the Australian.

With this must be associated the relative constancy in the relation of nasal height and width, the index of these two measurements ranging from 92 to 102, and in the great majority of tribes it lies between 93 and 98. This range is that most common among the native Australians.

The ear is well formed in all cases; the length of the ear-basis is rather short—averaging 45·7–48·6 mm., and the maximum length is also moderate, ranging from 56–59 mm.



A. MacTier Pirrie

A B C

FIG. 147.—MALFORMATIONS AND UNUSUAL CONDITIONS OF THE AURICLE FOUND IN THREE INDIVIDUALS

A Large antitragus—Dinka B Deep scaphoid fossa—Dinka C Absence of lobule—Dinka
This is a common condition among them

The greatest width varies from 35–38 mm. The lobule is short, from 13–15·4 mm., and in all these respects, and particularly in the length of the lobule, the measurements of the external ear are smaller than the average among the Australians.

Some illustrations of malformed auricles are appended. These show congenital defects in individuals rather than any racial character.

Pelvis. Measurements of the pelvis were made in two tribes only—the Dinkas and the Buruns. These go to show that the Burun pelvis is narrower in its principal dimensions, but that it is slightly larger in width between the tubercles on the outer margin of the crest of the ilium.

Hands and feet. The length of the hands (four fingers) does not vary to any marked degree in the tribes, usually measuring from 99–106 mm. In the Buruns, however, there is a noticeable difference, and the length on the average reaches as high as 112 mm.

The breadth of the hand similarly ranges in the great majority of tribes from 85–91 mm., the breadth in the Buruns being only 86 mm. But in this respect also one tribe—the Nuers—stands out from the others, and the average hand width is only 79·4 mm.

The same tribe shows a difference also in the length of the foot, for among them the average length is 241·4 mm., while in the other tribes the average ranges from 255–262 mm.

The breadth of the foot in the Fertits and Furs is unusually small, 93 and 95·8 mm., but the number of individuals measured is not sufficiently large for this character to be definitely laid down as being peculiar to them and distinctive.

In the other tribes the breadth ranges from 97–107 mm.

The latter figure is exceptionally large and is found in the Nyam-nyams.

C. M. Wenton

Fig. 148.—View of Bor, Jebel River

TABLE VII.—AVERAGE OF MEASUREMENTS AND INDICES. (ADDITIONAL TO FORMER TABLES)

	13 Males Nuba	4 Males Bari	4 Males Furawi	13 Males Nuer	4 Males Abyssinian	9 Males Gebelawi	7 Males Bongo	5 Males Fertit	60 Males Dinka	43 Males Burun	15 Males Fur	10 Males Nyam-nyam
Glabello-occipital length	195	190·25	199·2	193·8	187	192·7	188·2	190	195	189·7	192·8	191·8
Maximum breadth	148	149	149·5	140·9	145·2	147	144·4	148·8	142	150·1	144·4	151·5
Cephalic Index	*75·9*	*78·4*	*75*	*73*	*77·7*	*76·3*	*76·7*	*78·3*	*72·8*	*79·1*	*74·9*	*79*
Minimum fr. diam.	126·5	130·5	128·5	121·2	—	128·6	119·6	126·4	125	127·6	124	127·5
Upper face length	73·3	66·5	69	66·7	68·2	63·4	64·6	63	69·6	65	65·7	64·3
Total face length	115·6	113	121·5	112·6	—	114·6	113·4	114	111·2	115·1	114·6	119·4
Maximum intermalar breadth ...	127·6	128	127·5	123·1	—	127·5	118·4	127·6	124·7	129·1	127·5	132·8
Facial Index	*90*	*88*	*95*	*91*	—	*89*	*95*	*89*	*89*	*89*	*89*	*90*
Maximum interzygomatic breadth ...	139·6	143·5	143·5	136·2	—	138·3	133·4	138	138	136·5	139·4	141·2
External orbital breadth	115·3	116·5	114·7	112·1	—	114·3	111	109·2	112·4	113	113·8	117·2
Internal ocular breadth	36·1	36·75	37·7	35·5	—	33·1	35·1	35	35	35·2	37	35·1
Bi-auricular diameter	118	118·25	120·5	117·1	113·5	119·1	118	117	116·8	115·1	116·3	120·4
Auriculo-mental	120·4	125	125·5	122·8	—	124·6	—	124	123·4	124·2	122·5	129
Auriculo-alveolar	103·2	105	105·5	102·3	—	105·6	102·5	105·4	104·7	104·9	103	106·5
Auriculo-lower nasal	103·2	113	109·5	111·3	—	101	—	112	113	114·9	113	115·3
Auriculo-mid. nasal	102·5	104·25	103·2	100·5	—	104·6	—	102·25	102·1	102·1	101	103·5
Auriculo-upper nasal	95	96·5	98·5	96·1	—	98·8	—	96·25	97·1	96·1	95·6	97
Gnathic Index	*108*	*109*	*107*	*106·6*	—	*107*	—	*109*	*107·2*	*109*	*107*	*109*
Auriculo-glab.	105·6	106	107	106·3	—	106·2	—	104·75	107·2	105·7	104·3	105·5
Auriculo-ophryal	114·2	118	116	118·1	—	116	—	116·75	117·9	112·9	115·6	114·1
Auriculo-frontal (max.)	122·8	125·5	125·7	124·3	—	125·5	—	128·75	126·6	123·2	125·3	122·8
Auriculo-vertical	136·9	132·5	133·7	135·6	135·5	131·3	135·7	135·4	135·8	135	133·6	135·8
Vertical Index	*69·7*	*69·53*	*67·2*	*70*	*72·5*	*68*	*72·1*	*71·2*	*69*	*71·1*	*68·9*	*70·7*
Auriculo-occipital	116	111·75	114·7	118·5	—	115	—	107·75	114·3	119·7	109·4	114·7
Auriculo-inial	81·5	90	94	94·1	—	93·5	—	90	89·7	96·5	86·8	89·5
Maximum circumference	540	489·5	493·75	543·4	—	550·8	547·5	550·75	544	545·2	540·2	550·7
Longitudinal arc	361·4	353·75	370	366·6	—	355·8	350	348·75	368·3	335·9	352·5	359·3
Transverse arc	335	330	327·5	342·2	—	340	345	341·25	348·5	337·9	336	336·8
Nasal height	43·1	45	43·2	43·3	—	43·4	44·5	43·8	44·2	44·3	43·8	46·9
Nasal depth	17·5	17·25	20	17·6	—	18·2	19·2	18·4	17·8	18·2	18·3	17
Nasal length	41·6	43	44·7	42·7	—	41·6	44·4	43·4	44	44	42·7	44·9

TABLE VII.—AVERAGE OF MEASUREMENTS AND INDICES (*continued*)

	13 Males NUBA	4 Males BARI	4 Males FURAWI	13 Males NUER	4 Males ABYSSINIAN	9 Males GEBELAWI	7 Males BONGO	5 Males FERTIT	60 Males DINKA	43 Males BURUN	15 Males FUR	10 Males NYAM-NYAM
Nasal breadth	43·6	42·75	44·2	41	—	44·4	42·2	43	40·9	42·6	42·5	43·7
Nostril length	10	10·25	10	10·3	—	10·4	11·5	11·8	10·1	11·1	10·2	10
Nostril breadth	13·6	12·25	14	14	—	14·5	15·4	15·2	13·5	14·7	14·8	14·4
Nasal Index	*100*	*95*	*102*	*97*	—	*102*	*94*	*98*	*92*	*96*	*97*	*93*
Ear basis length	46·6	47·5	45·7	45·2	—	45·2	47·4	48·6	47·6	46	46·9	48·9
Ear length (maximum)	57·7	58·25	58·2	58·8	—	56·6	58·4	56·4	57·4	59·8	58·2	59
Ear breadth (maximum)	33·4	34	31	36·6	—	33·2	36	33·2	34·2	38·2	36	32·5
Dar. tub. to tragus	28·5	32·5	29·2	29·9	—	29	—	32·5	29·7	33·2	28	32
Highest pt. to incisura intertragcia ...	45·3	48	47	47	—	45	—	45·25	46·4	47·6	45·4	47·4
Lobule length	14·3	13	14·7	13·2	—	13·5	13·2	15·4	13·7	14·9	13·6	15·2
Chest circumference expanded ...	—	—	—	—	—	—	—	—	770·4	890·1	—	—
Chest circumference unexpanded ...	—	—	—	—	—	—	—	—	783·1	858·7	—	—
Upper arm length	328·3	336·25	335	347·9	—	325	327·5	343	335·6	321·9	324·2	320
Forearm length	292·2	308·25	307·5	310·8	—	287·2	286·8	309	307·6	299·1	297·8	294·3
Thumb length	—	117	122·5	115·2	—	108	110	101	110·5	120·5	108·3	68·4
Four fingers length	—	100·75	106	104·1	—	101·25	101·5	102	101·6	112·4	99·3	100
Hand breadth	—	91	91·5	79·4	—	91	84	85	85	86·5	85·2	90
Thigh length	423	469·75	470	452·8	—	434·3	430·8	438	463·2	465·8	407	433
Leg length	417	420	425	444·2	—	401·1	420	412	439	440·8	396	421
Great toe	—	259·75	—	248·8	—	264	—	260	270·2	264·7	253·3	245
Foot length 2nd toe	—	255·25	—	241·4	—	262·5	—	253	262·8	262·1	256·4	260·5
Foot breadth	—	100	—	99	—	99·5	—	93	97·5	101·7	95·8	107·5
Span of arms	1809	1820	1865	1890	—	1780	1795	1762	1877	1834·1	1769·3	1822·2
Stature	1694	1741·25	1717	1795·7	—	1727	1692	1708	1801·6	1759·4	1682·5	1724·4
Ant. Sup. Il. Sp. breadth	—	—	—	—	—	—	—	—	225·5	219·5	—	—
Iliac Tub. breadth	—	—	—	—	—	—	—	—	255	262·6	—	—
Post. Sup. Il. Sp. breadth	—	—	—	—	—	—	—	—	108	99·9	—	—
Ext. Conj. Pelvis	—	—	—	—	—	—	—	—	243·4	196·4	—	—

A. MacTier Pirrie

Fig. 149.—Possibly a Case of Hyperdactylism among Buruns: Left Hand

Fig. 150.—Same: Right Hand

A. MacTier Pirrie

Fig. 151.—Burun Woman

C. M. Weston

Fig. 152.—Young Women of Bor: Dinka Tribe

S. C. Dunn

Fig. 153.—Omda's Hut, Jebel Keili. Built in stone to keep out white ants

S. C. Dunn

Fig. 154.—Diluka (Native Dance) of the Burta Tribe, Abyssinian frontier, east of Burun country

FIG. 155.—Nuba

FIG. 156.—Nuba

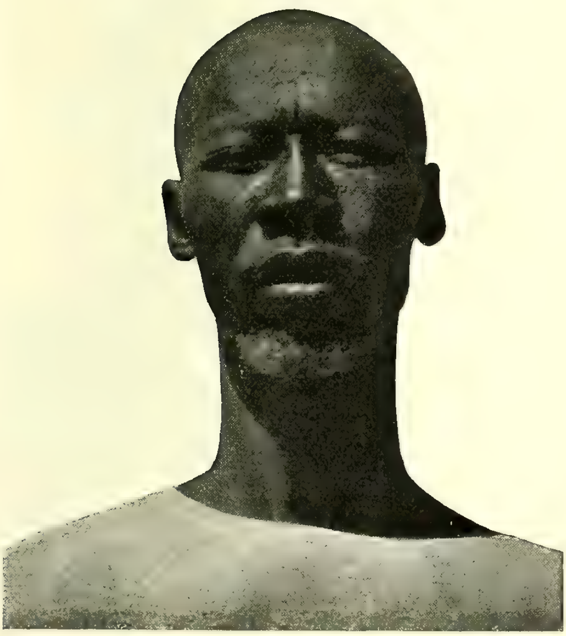


FIG. 157.—Fertit

FIG. 158.—Fertit

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SUDANESE TYPES

FIG. 159. Nuba

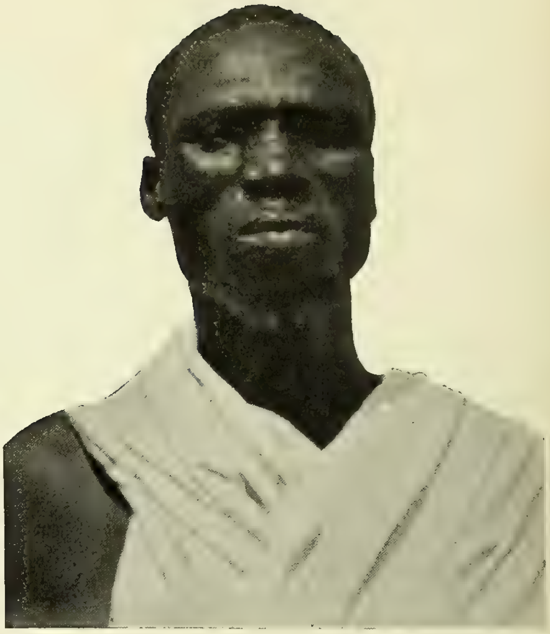

FIG. 160.—Nuba

FIG. 161.—Nuba Sheik

FIG. 162.—Nuba Sheik

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SUDANESE TYPES

FIG. 163.—Results of Smallpox

FIG. 164.—Same, profile view

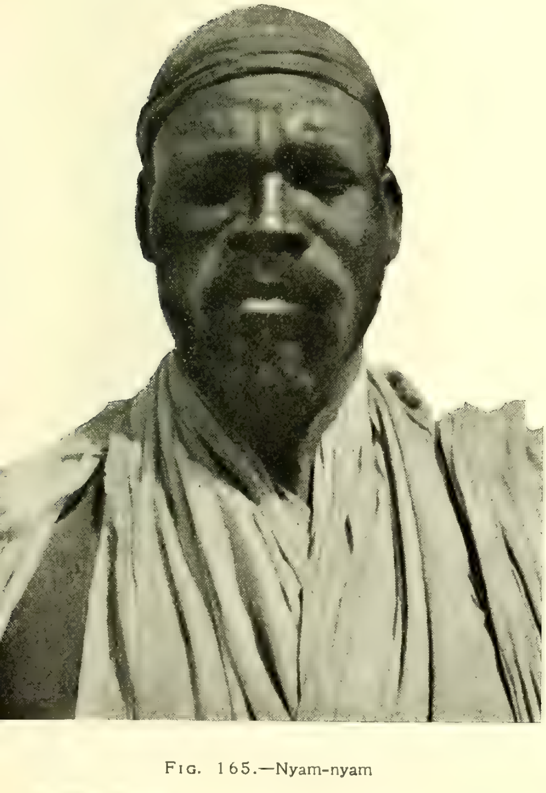


FIG. 165.—Nyam-nyam

FIG. 166.—Nyam-nyam

A. MacTier Pirrie

SUDANESE TYPES

Fig. 167.—Burun

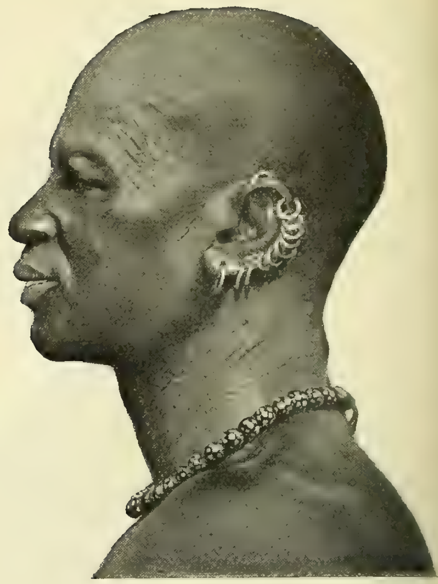


Fig. 168.—Burun, profile, showing earrings

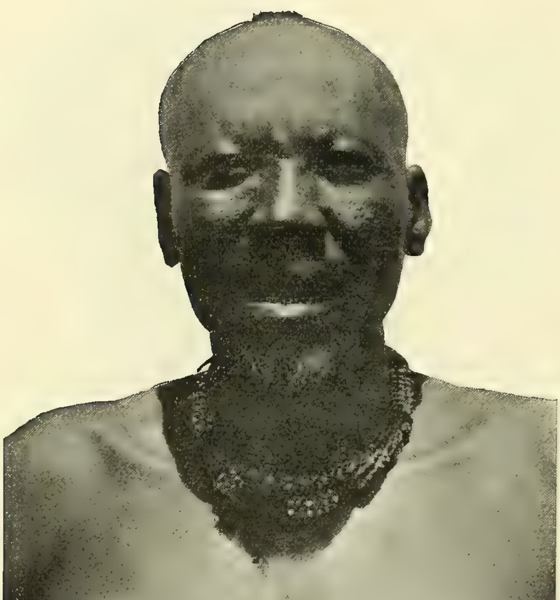


Fig. 169.—Burun

Fig. 170.—Burun

A. MacTier Pirrie

Sudanese Types

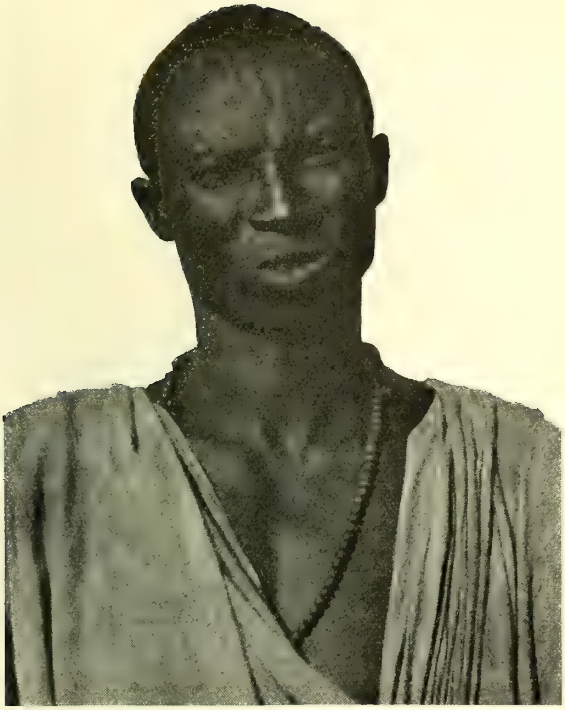


Fig. 171.—Fung, from Darfur

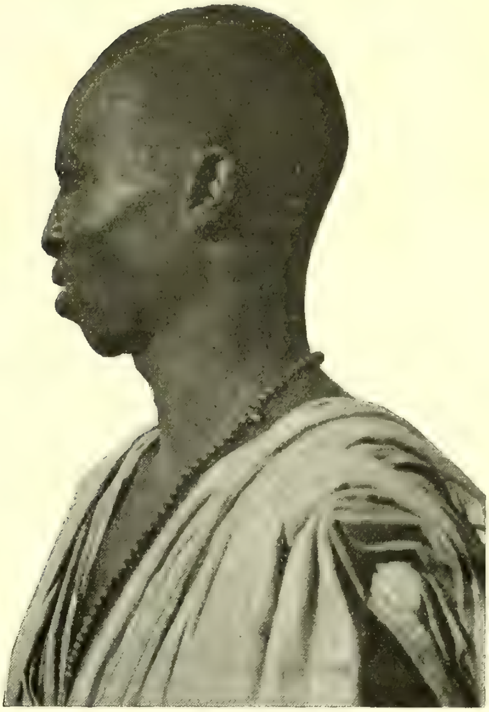


Fig. 172.—Fung, from Darfur

Fig. 173.—Fur

Fig. 174.—Fur

A. MacTier Pirrie

Sudanese Types

Fig. 175.—Kordofan

Fig. 176.—Kordofan

Fig. 177.—Kordofan

Fig. 178.—Kordofan

A. MacTier Pirrie

Sudanese Types—Prisoners in Khartoum Gaol

Fig. 179.—Dongolawi

Fig. 180.—Dongolawi

Fig. 181.—Kordofan

Fig. 182.—Kordofan

A. MacTier Pirrie

Sudanese Types—Prisoners in Khartoum Gaol

Fig. 183.—Dinka

Fig. 184.—Fur

Fig. 185.—Shilluk

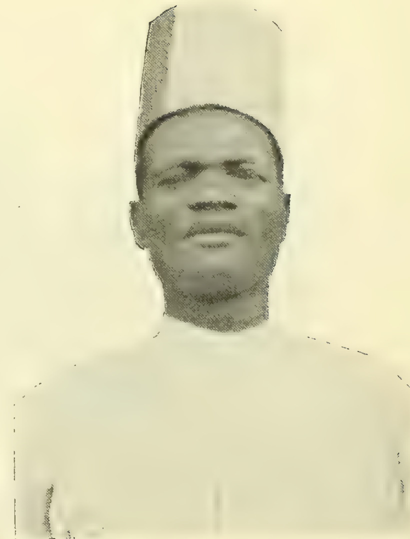


Fig. 186.—Nuba

Fig. 187.—Nyam-nyam

Fig. 188. Gebelawi

Fig. 189. Nuba

Sudanese Types—
Soldiers at Khartoum

A. MacTier Pirrie

Fig. 190.—Nyam-nyam

Fig. 191.—Nyam-nyam

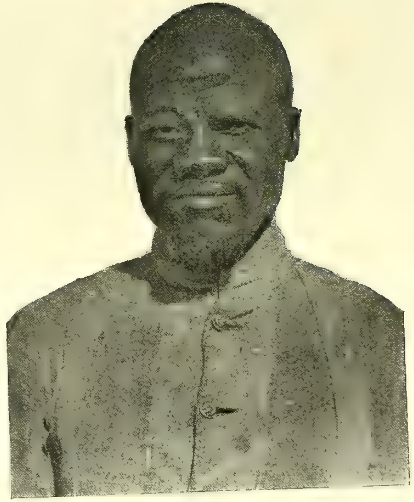


Fig. 192

Fig. 193

Fig. 194.—Dongolawi

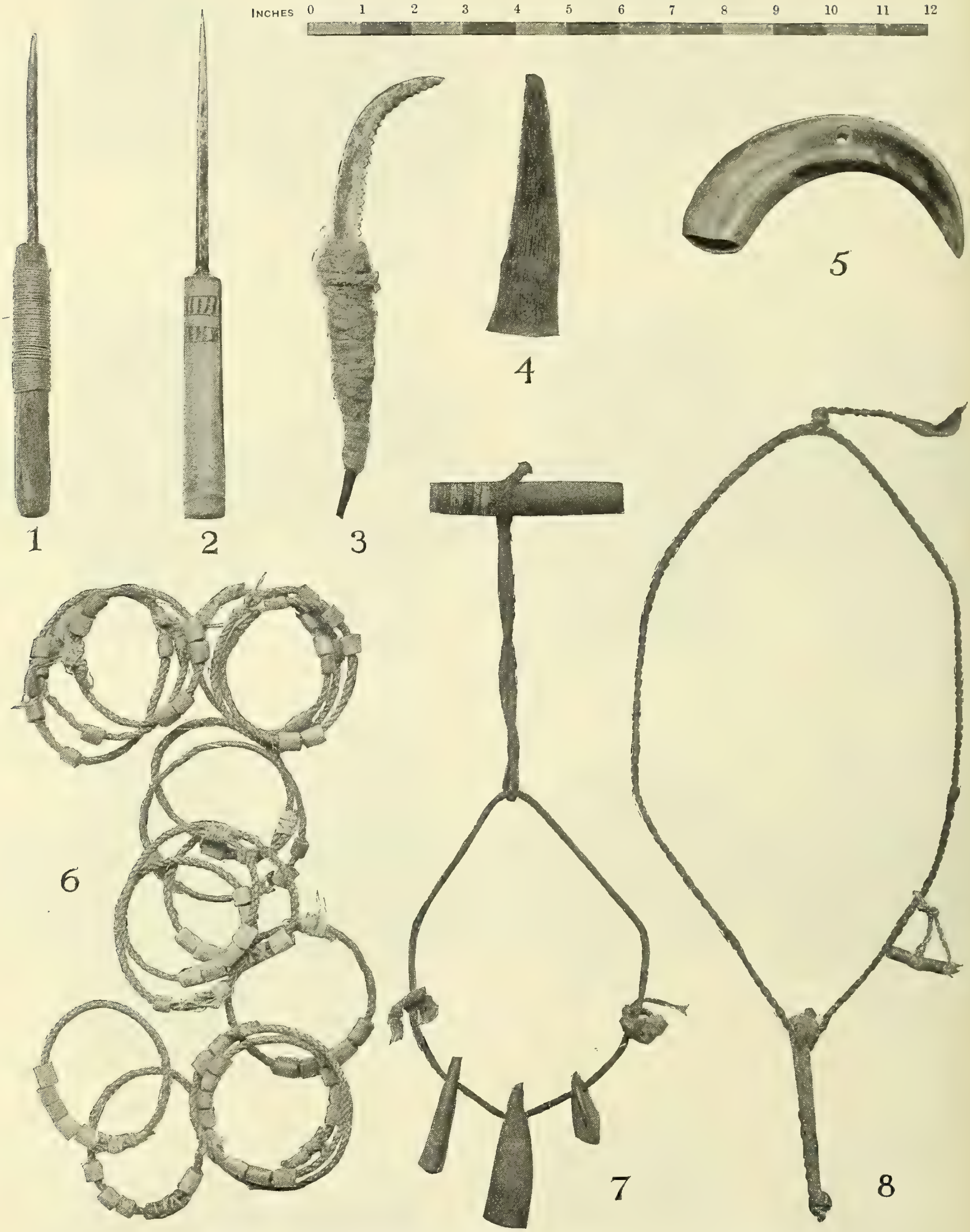
Fig. 195.—Dongolawi

Fig. 196.—Nuer immigrant

Fig. 197.—Nuer immigrant

Sudanese Types

PLATE XLIV



ETHNOGRAPHICAL SPECIMENS COLLECTED BY DR. A. MACTIER PIRRIE

1., 2. Instruments of iron with wood handle, used for extracting lower front teeth; length, nine inches and nine-and-three-quarter inches respectively. Tribe—Burun, from Burun Country.

3. Grass-cutter; iron, curved and serrated blade, handle bound with twine; length, nine inches. Tribe—Shilluk, from Taufikia.

4. Cupping instrument; cowhorn; length, five inches. Tribe—Dinka, from Upper Nile Provinces (inland). (*See* Fig. 200, showing the instrument in use, and also note on *page* 380.) An identical cupping horn from Shetland, N.B., is in the Royal Scottish Museum

5. Tooth of Warthog, worn round the neck. Tribe—Hameg, near Keili, Abyssinian Frontier.

6. Anklets worn by a married woman, but discarded after birth of first child. Tribe—Burun, from Burun Country.

7. Necklace with horn-tips filled with fat, and a root (a charm to attract women), also a whistle; the seeds are a charm against lions. Tribe—Burun, from Burun Country.

8. Necklace, with root suspended; a medicine for dyspepsia. A little of the root is chewed. Tribe—Burun, from Burun Country, N.

Notes on the Ethnographical Specimens collected by Dr. A. MacTier Pirrie

by

D. J. Vallance

Curator, The Royal Scottish Museum, Edinburgh

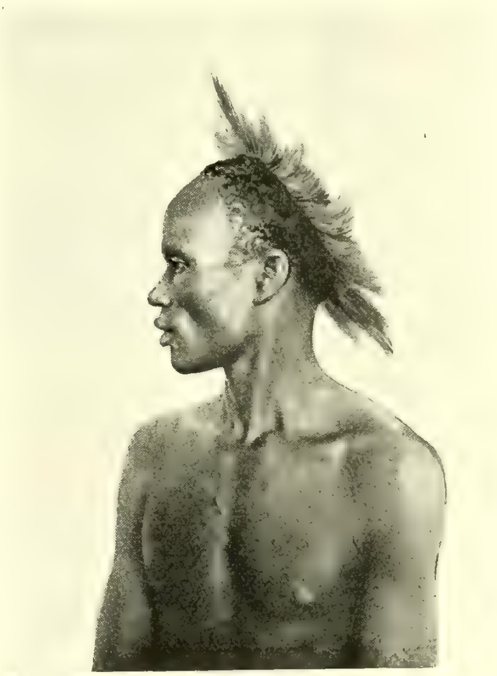
The illustrations shown in Plates XLIV.–XLVIII. have been prepared from the specimens collected by Dr. MacTier Pirrie while travelling on the route described by Dr. Waterston and shown in Fig. 105. The objects, with few exceptions, are from three tribes—the Shilluks and the Dinkas, who occupy most of the land on the banks of the White Nile south of Melut, and the Buruns, whose country lies to the north of the River Sobat. A few objects are from the Nuer tribe living along and to the south of that river.

Representative collection from Burun country

Nearly one half of the collection comes from the Burun country, a district which has been so little explored that few specimens illustrating the habits and handicrafts of the people are to be found in ethnographical collections. The material for reference and comparison is, therefore, still limited, and some detailed information as to the habits and conditions of life of these people is to be desired. It will, however, be noticed that the Burun objects, gathered together by Dr. Pirrie, are fairly representative of the belongings of a native people. The specimens include weapons, dress, musical instruments, tobacco pipes,

R. W. Felkin

Fig. 108



R. W. Felkin

Fig. 109

Shilluk wearing Circular Head-dress of Antelope's Mane

surgical and medical appliances, as well as a few objects of domestic use. The Burun arrows (Plate XLV., fig. 9), with their gourd sheath to protect the points, are notched to receive poison and probably also to allow of the point breaking off and remaining in the wound. Unfortunately there is no bow or shield; these would also be an essential part

Poisoned arrows

of the Burun's fighting equipment. The Nuer shield (Plate XLV., fig. 2) is probably of the same form as that of the Burun. It is a slightly developed form of the simple parrying stick, grasped in the middle, and so swung about to ward off arrows. This specimen is little more than a part of a branch of a tree rounded at the ends, and thick enough to allow of the grip being cut in the solid wood.

Comparison with native Australians

The throwing-sticks (Plate XLVI., figs. 2, 3, and 4), as is the case with other similar weapons found in Africa, bear a strong resemblance to the boomerang of the Australian native, and it is curious to find that the coils of rope or twine (Plate XLVII., figs. 9 and 10) worn round the neck by certain of the hill tribes of Burun also find their exact counterpart, both as to form and use, among the Australians. It is scarcely to be expected that dress should form any considerable part of the collection, but the two specimens (Plate XLVII., figs. 2 and 3) are interesting from their likeness to the women's dress among the Masai and also the Kaffirs, peoples who, in the opinion of many authorities, moved to the districts they now occupy from a more northerly part of the continent. Head-rests of a form almost identical with that in Plate XLVII., fig. 8, are found among the Nyam-nyams, and fig. 7 on the same Plate—a branch of a tree lopped so as to suggest an animal form—has its counterpart in a head-rest in the New Hebrides collection in the Royal Scottish Museum.

Musical instruments

The musical instruments are of the lyre type (Plate XLVI., figs. 5 and 6), and are similar to the Dinka form (*see* Fig. 132), the strings being stretched to a fixed pitch, and without tuning pegs. The whistle ("chillong"), fig. 7, is shown in Fig. 142 slung across the back of its Burun owner. Plate XLIV., figs. 1 and 2, are instruments for extracting the lower front teeth, and Plate XLIV., figs. 7 and 8, are worn on the neck as charms. Fig. 7 combines a charm against lions with a charm to attract women, probably a valued possession in a tribe where the males are so very largely in the majority. Fig. 8 is a cure for dyspepsia. The mouse or rat trap (Plate XLVI., fig. 8) is identical in every respect with a trap from the Congo district in the Brussels Museum.

Tobacco pipes

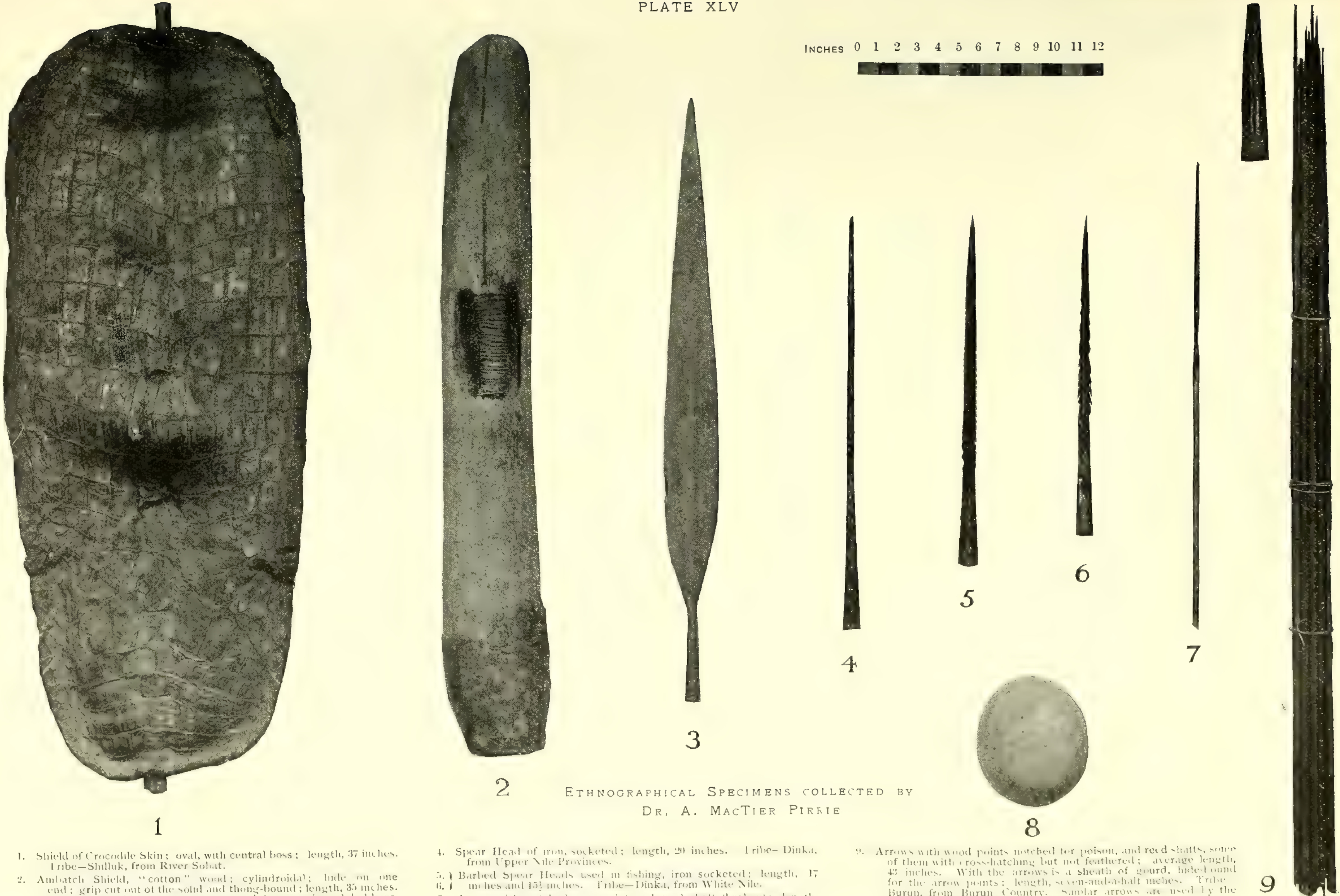
The Burun tobacco pipe (Plate XLVIII., fig. 5) has a clay bowl with a plain stem of wood jointed in the middle. Iron ribbon is wound round it at intervals, and the mouthpiece and bowl are each separated from the stem by a thin circle of copper. The hookah-shaped water pipe (Plate XLVIII., fig. 7) is a form copied probably from the Arabs or from the neighbouring Gallas on the Abyssinian frontier. In Plate XLVIII., fig. 6, the stem is thicker and there is no metal covering, but the mouthpiece is encased by a piece of the skin of the Nile Bichir *(Polypterus)*. These Burun pipes differ from those of the Shilluk (Plate XLVIII., figs. 3 and 4), which have a larger and rounder bowl with the characteristic gourd mouthpiece.

Fig. [illegible].—Native Method of Cupping

Native tobacco

This mouthpiece is filled with bast or fine fibre, and after the pipe has been smoked for a time (mostly by the women), the bast, which has become saturated with tobacco juice, is taken out and is chewed by the men. The double-bowled pipe (Plate XLVIII., fig. 4) is a somewhat rare form. On the same Plate, figs. 8 and 9 are snuff boxes made from the fruit of the Oncoba,

PLATE XLV



ETHNOGRAPHICAL SPECIMENS COLLECTED BY
DR. A. MACTIER PIRRIE

1. Shield of Crocodile Skin; oval, with central boss; length, 37 inches. Tribe—Shilluk, from River Sobat.
2. Ambatch Shield, "cotton" wood; cylindroidal; hide on one end; grip cut out of the solid and thong-bound; length, 35 inches. Used for catching thrown spears and for parrying club blows. Tribe—Nuer, from Lake Nuer Country.
3. Shilluk Spear Head of native manufacture, iron, socketed; length, 29½ inches.
4. Spear Head of iron, socketed; length, 20 inches. Tribe—Dinka, from Upper Nile Provinces.
5., 6. Barbed Spear Heads used in fishing, iron socketed; length, 17 inches and 15½ inches. Tribe—Dinka, from White Nile.
7. Arrow with notched iron point and reed shaft (broken); length, 22½ inches. Tribe—Gebelawi, from Lake Nuer Country.
8. Ostrich Egg used for carrying water.
9. Arrows with wood points notched for poison, and reed shafts, some of them with cross-hatching but not feathered; average length, 43 inches. With the arrows is a sheath of gourd, hide-bound for the arrow points; length, seven-and-a-half inches. Tribe—Burun, from Burun Country. Similar arrows are used by the natives of New Hebrides.

and figs. 1 and 2 are cakes of tobacco specially prepared by the natives for smoking in these clay-bowled pipes. The most interesting of the Shilluk objects are (Plate XLVII., figs. 4 and 5) the head-dress and collar of felted hair, and (fig. 11) the circular head ornament which is shown in position in Figs. 198 and 199. The Dinka method of cupping is shown in Fig. 200, and is thus described by a witness of the operation : " The skin was wetted and the ends of five cowhorns with holes bored in their ends were applied. The doctor then sucked the ends and plugged the holes quickly with some cotton which he had in his mouth. Then, after a short while, when the pores had been opened, the horns were removed and incisions made with a small knife. The horns were then stuck on and sucked as before. After a little they were taken off and found to contain a lot of thick blood that had been drawn from the skin. The last operation was to rub the incisions with butter."[1] The use of the horn for this purpose is widely spread in Africa, and it is interesting to note that it has been applied in the same way in Scotland. A specimen identical with that just referred to, but coming from Shetland, is in the collection of the Royal Scottish Museum.

Dinka method of Cupping

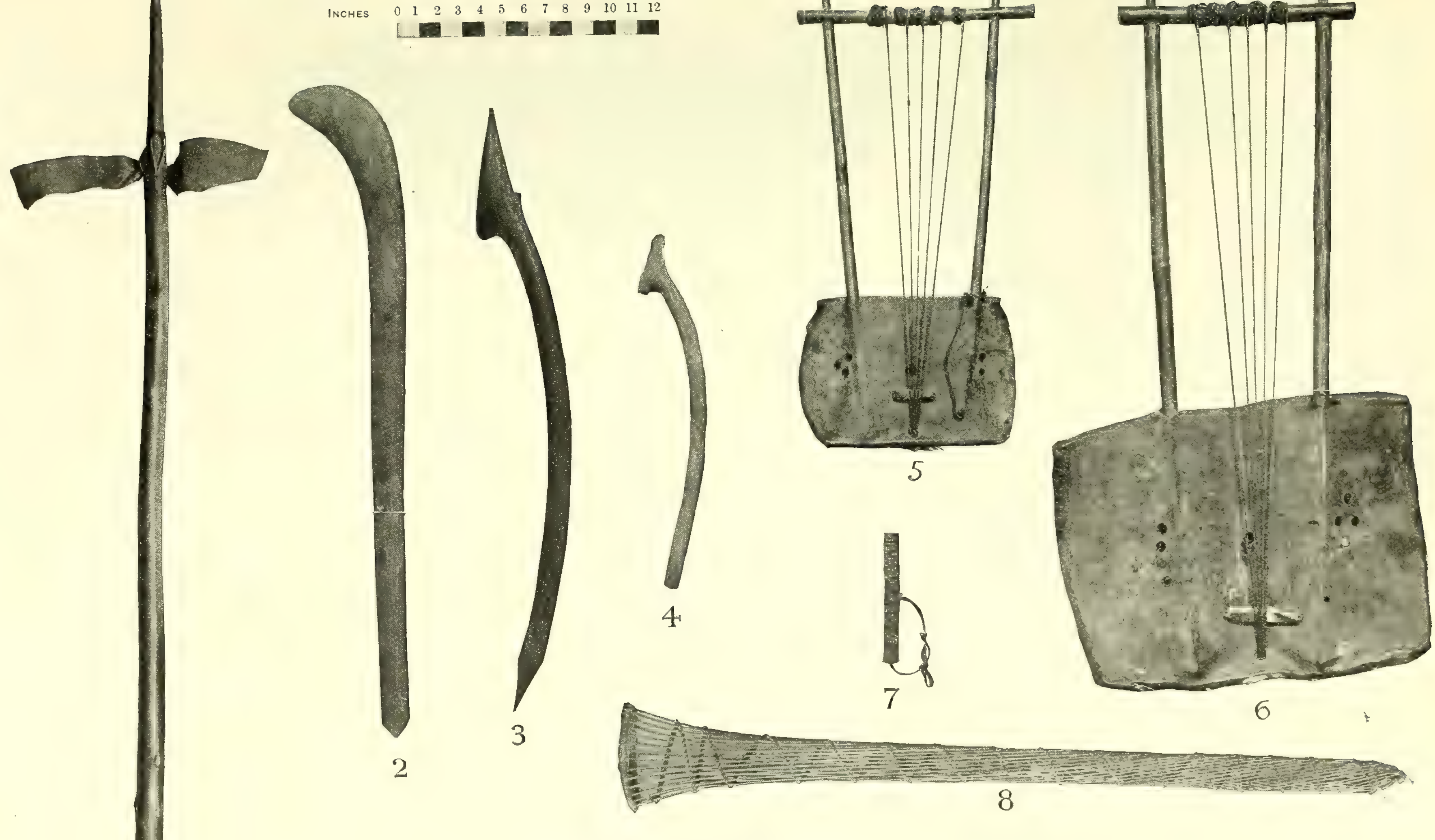
The objects in the collection are illustrated and described separately on Plates XLIV.–XLVIII.

C. M. Wenyon

Fig. 201.—View of Bor

[1] " From the Niger to the Nile," Boyd Alexander, *page* 43.

PLATE XLVI



ETHNOGRAPHICAL SPECIMENS COLLECTED BY
DR. A. MACTIER PIRRIE

1. Club of wood with knotted hide on handle and leather wrist attachment; length, 43 inches. Tribe—Shilluk, from Sobat River.
2. Throwing-Stick with cross-hatching on the grip. Tribe—Burun, from Burun Country. (*See* Figs. 146 and 154.) Similar to the Australian Langeel.
3. Throwing-Stick. Tribe—Burun, from Burun Country.
4. Boy's Throwing-Stick. Tribe Burun, from Burun Country.
5, 6. Musical Instruments, called "Chong-Kong." Tribe—Burun, from Burun Country. (The Dinka form is shown in Fig. 132.)
7. Whistle, called "Chillong": inside is a cleaner of feathers. (The whistle is shown carried across the back in Fig. 142.)
8. Mouse or Rat Trap, of openwork split cane; length, three feet. Tribe—Burun, from Burun Country.

PLATE XLVII

ETHNOGRAPHICAL SPECIMENS COLLECTED BY DR. A. MACTIER PIRRIE

1. Dress of grass with a few plaited strands and mounted with cowrie shells, worn by girls and young women. Tribe—Nuer, from Lake Nuer Country. A [illegible]

2, 3. Dressing of leather [illegible] beads [illegible]. Tribe [illegible]

4. Shilluk [illegible]

5. [illegible]

6. Armlet [illegible]. Tribe—Shilluk, from [illegible]

7, 8. [illegible]

9, 10. [illegible] Burun. Tribe [illegible] Burun [illegible] Kurmuk, Abyssinian Frontier. Similar [illegible] Northern Abyssinia.

11. Head Ornament [illegible]. It is worn on [illegible]

PLATE XLVIII

ETHNOGRAPHICAL SPECIMENS COLLECTED BY
DR. A. MACTIER PIRRIE

1.⎫ Two cakes or lumps of tobacco. These exactly resemble cakes or lumps of tobacco used by the lower order of natives in N. India. It is said that they are prepared by mixing roughly powdered dry tobacco leaves with a fermented solution of sugar, the mixture being worked into a cake, which in India is called "Tambaku." It is smoked in earthen or clay pipes, called "Chillum." The substance should be sufficiently
2.⎭ soft to allow of pieces to be broken off with the fingers.

3. Pipe: the bowl of red clay, the stem of cane, the mouthpiece gourd, with hide attachment; length, 30 inches. Tribe—Shilluk, Tonga Country. (*See* Figs. 111 and 123.)

4. Double-bowled Shilluk Pipe. Rare. The bowls of clay, the stem of cane, with a gourd mouthpiece (imperfect): length, 28 inches. Tribe—Shilluk, from Taufikia.
Iron pincers attached.

5. Pipe: the bowl of black clay, the stem of wood in two pieces ornamented with bands of rude cross-hatching and bound round at mouthpiece and about the middle with iron ribbon. Tribe—Burun, from Burun Country, S. (*See* Fig. 142.)

6. Pipe: the bowl of black clay, the stem thick and of wood, the mouthpiece covered with fish-skin, the Nile Bichir (*Polypterus*). Tribe Burun, from interior of Burun Country.

7. Water Pipe on the principle of the hookah, formed of a gourd with short wood pipe inserted to support the clay bowl. Iron ribbon wound round mouthpiece. Thong attachment. Tribe—Burun, from Burun Country, S.

8.⎫ Snuff Boxes. Fruit of *[illegible]* order *[illegible]*. Tribe Burun,
9.⎭ from Burun Country

C. M. Wenyon

Fig. 202.—Fort Wau, Bahr-El-Ghazal Province

C. M. Wenyon

Fig. 203.—Native Huts in Wau

REPORT

OF THE

CHEMICAL SECTION

OF THE

WELLCOME RESEARCH LABORATORIES GORDON COLLEGE, KHARTOUM

BY

WILLIAM BEAM, M.A., M.D., F.I.C., F.C.S.

The following is a summary of the analyses and examinations made since the issue of the Second Report of these Laboratories, in 1906, up to and including the month of May, 1908. List of examinations

River waters	110	Plants	13
Well waters	59	Toxicological and medico-legal examinations	22
Gums	213	Pharmaceutical preparations	3
Soils, clays, etc.	61	Petroleum	2
Limestones and limes	40	Indigo	3
Other minerals and ores	52	Urines	7
Fertilizers	6	Colouring matters	4
Grains	69	Soap	1
Oil-bearing seeds, etc.	19	Lime juice	1
Oils and fats	7	Wood preservative	1
Liquors and beverages	21	Boiler scale	1
Sugar-cane and beet	3	Salt	2
Milks	22	Coal	2
Preserved milks	9	Bleaching powder	2
Other food materials	16	Miscellaneous	12

Total, 783

A very large share of the analytical work has been carried out by the assistant chemist, Mr. Goodson.

Special research on gum-arabic

Owing to the greatly increased volume of routine work, the opportunities for pure research have not been many; but the examinations of the Nile waters, and the very great number of examinations of gum, were all in this direction. We were very fortunate this year in being able to secure the services of Mr. E. S. Edie, B.Sc., Carnegie Research Fellow, who was detailed by the Committee of the Carnegie Trust to carry out researches in Sudan gum. Mr. Edie's work, as well as our own, was very much hampered by the failure, through a misunderstanding, of the Woods and Forests Department to supply the essential samples of gum, and, further, by the fire which destroyed the bacteriological laboratory in which he was carrying out his experiments on the bacterial production of gum. Notwithstanding these misfortunes, Mr. Edie has been able to offer a very substantial contribution to our knowledge of the chemistry of gums, as will be seen by reference to his Report, which is attached to this.

Chemical Composition of Nile Waters

The water of the Blue and White Niles

In the Second Report of these Laboratories the results of periodical examinations of the waters of the Blue Nile and White Nile were given for a period of a year ending November, 1905. The examinations continued up to the month of May, 1907, were more complete both as to the determinations of amount of suspended material and of the quantity and nature of the dissolved matter. These results, along with those obtained for the previous year, are tabulated on the following pages. The figures representing solid matter in suspension are usually the average of several (in the flood season, weekly) examinations. The others represent determinations on a single sample collected about the middle of each month.

As before, the samples from the Blue Nile were taken opposite the far end of Burrè, about a mile beyond the built-up portion of Khartoum. Those of the White Nile water were collected from a point about two miles above its junction with the Blue Nile.

The proportion of CO_3 recorded represents simply the measure of the alkalinity determined by direct titration with acid.

BLUE NILE, 1905

	January	February	March	April	May	June	July	August	September	October	November	December
Solids in suspension	6·61	4·00	8·95	6·50	7·00	7·00	472·00	993·50	—	110·00	66·00	17·37
Solids in solution	115·00	—	120·00	—	130·00	165·00	—	—	—	110·00	103·00	105·60
"Free" ammonia... ...(NH_3)	0·006	—	0·020	—	0·030	0·032	—	—	—	0·018	0·015	0·005
"Albuminoid" ammonia (NH_3)	0·075	—	0·160	—	0·180	0·198	—	—	—	0·169	0·138	0·094
Oxygen consumed in 10 min. at 100° C...	0·80	—	0·65	—	0·84	0·89	—	—	—	3·65	2·20	1·60
Nitrates ... ... (N)	0·015	—	0·029	—	0·050	0·054	—	—	—	0·040	0·035	0·041
Nitrites .. .. (N)	none	—	none	—	none	none	—	—	—	none	none	none
Chlorides ... ... (Cl)	1·50	—	2·68	—	4·51	4·70	—	—	—	2·64	1·86	1·70
Sulphates ... ... (SO_4)	7·00	—	7·23	—	7·60	7·69	—	—	—	4·97	4·80	4·41
Carbonates... ... ... (CO_3)	47·45	—	55·80	—	57·09	59·89	—	—	—	44·52	40·71	40·71
Calcium ... ... (Ca)	21·81	—	—	—	—	25·53	—	—	—	—	—	15·58
Magnesium... ... ... (Mg)	4·65	—	—	—	—	5·89	—	—	—	—	—	2·50
Potassium ... ... (K)	1·52*	—	—	—	—	1·90*	—	—	—	—	—	2·12*
Sodium ... ... (Na)	6·01*	—	—	—	—	7·81*	—	—	—	—	—	7·95*
Silica ... ...(SiO_2)	24·00	—	—	—	—	23·50	—	—	—	—	—	—

WHITE NILE, 1905

	January	February	March	April	May	June	July	August	September	October	November	December
Solids in suspension	70·84	67·00	55·00	56·19	52·20	49·00	75·7	142·6	26·5	32·0	44·00	40·20
Solids in solution	160·00	—	177·50	—	196·00	198·00	—	—	—	140·00	142·00	188·00
"Free" ammonia ... ...(NH_3)	0·02	—	0·02	—	0·024	0·023	—	—	—	0·016	0·019	0·01
"Albuminoid" ammonia...(NH_3)	0·34	—	0·23	—	0·260	0·300	—	—	—	0·260	0·284	0·252
Oxygen consumed in 10 min. at 100° C	6·15	—	8·53	—	8·00	8·70	—	—	—	6·00	6·40	6·12
Nitrates .. .. (N)	0·095	—	0·091	—	0·098	0·089	—	—	—	0·078	0·089	0·072
Nitrites ... . (N)	none	—	none	—	none	none	—	—	—	none	none	none
Chlorides ... . (Cl)	5·39	—	9·15	—	11·41	11·50	—	—	—	5·58	5·58	4·91
Sulphates ... ... (SO_4)	none	—	0·95	—	1·00	—	—	—	—	none	none	none
Carbonates... ... ... (CO_3)	57·60	—	85·90	—	90·48	94·00	—	—	—	54·23	54·80	52·00
Calcium ... ... (Ca)	13·20	—	—	—	—	20·96	—	—	—	—	—	—
Magnesium ... ... (Mg)	3·98	—	—	—	—	6·49	—	—	—	—	—	—
Potassium ... ... (K)	8·90*	—	—	—	—	14·27*	—	—	—	—	—	—
Sodium ... ... (Na)	23·40*	—	—	—	—	36·89*	—	—	—	—	—	—
Silica ... ...(SiO_2)	25·00	—	—	—	—	21·00	—	—	—	—	—	—

* The proportions of K_2O and Na_2O to which these are equivalent have been erroneously stated at about twice their value in a recent publication of the Survey Department of Egypt, "The Chemistry of the River Nile." The analytical data were furnished that Department in advance of the present publication.

BLUE NILE, 1906

	January	February	March	April	May	June	July	August	September	October	November	December
Solids in suspension	7·90	11·64	5·90	7·8	28·73	270·5	1004·00	1964·0	755·5	279·60	108·85	22·0
Solids in solution	166·10	—	134·90	148·35	141·3	118·8	96·80	135·20	109·20	106·4	130·30	109·60
"Free" ammonia ... ... (NH_3)	—	—	0·005	0·003	0·027	0·011	0·029	0·034	0·006	0·008	0·007	0·005
"Albuminoid" ammonia (NH_3)	—	—	0·110	0·166	0·259	0·396	1·114	2·256	1·232	0·260	0·168	0·172
Oxygen consumed in 10 min. at 100° C	1·75	—	2·35	2·45	3·57	4·50	42·25	56·00	15·48	9·48	3·12	1·67
Nitrates ... ... (N)	—	0·037	0·038	0·031	0·550	0·336	0·422	0·707	0·160	0·185	0·104	0·044
Nitrites ... ... (N)	—	none	none	none	none	none	none	none	none	none	none	none
Chlorides ... . (Cl)	1·70	1·79	1·99	3·02	2·20	2·08	1·89	1·89	1·70	1·51	1·78	1·98
Sulphates ... ... (SO_4)	5·06	7·24	6·50	9·30	7·74	7·09	2·14	11·52	3·62	3·46	6·42	6·58
Carbonates ... ... (CO_3)	44·93	48·57	49·54	58·94	56·90	53·76	38·52	54·54	42·40	43·03	42·50	47·06
Calcium ... ... (Ca)	16·15	13·75	19·46	22·05	21·28	20·26	16·29	25·82	19·97	16·69	21·06	17·48
Magnesium ... ... (Mg)	5·81	7·48	7·41	8·40	10·02	4·73	7·80	7·70	7·35	6·47	7·61	8·16
Potassium ... ... (K)	2·19*	—	—	1·87*	2·78*	2·78*	2·36*	2·02*	2·50*	1·95*	2·86*	2·00*
Sodium ... ... (Na)	9·61*	—	—	12·60*	8·66*	8·83*	4·88*	7·70*	4·43*	6·47*	1·89*	3·86*
Silica ... ... (SiO_2)	22·30	—	23·20	22·80	—	17·20	22·00	16·80	23·60	20·80	30·40	14·40

WHITE NILE, 1906

	January	February	March	April	May	June	July	August [1]	September	October	November	December
Solids in suspension	61·50	55·70	49·80	49·05	49·10	81·25	46·77	167·27	69·2	27·50	60·20	48·20
Solids in solution	191·00	—	189·80	205·20	216·50	189·60	163·60	161·8	135·40	112·00	176·20	121·60
"Free" ammonia ... (NH_3)	—	—	0·003	0·008	0·010	0·010	0·019	0·020	0·009	0·015	0·010	0·008
"Albuminoid" ammonia (NH_3)	—	—	0·240	0·392	0·320	0·458	0·288	0·345	0·161	0·190	0·333	0·269
Oxygen consumed in 10 min. at 100° C	5·49	—	5·75	5·75	6·20	6·15	5·70	9·77	4·79	5·60	5·43	5·00
Nitrates ... ... (N)	—	0·065	0·068	0·031	0·044	0·160	0·099	0·285	0·032	0·044	0·103	0·033
Nitrites ... . (N)	—	none	none	none	none	none	none	none	none	none	none	none
Chlorides ... . (Cl)	5·48	8·32	10·96	15·10	13·60	12·28	9·45	4·34	7·94	4·53	3·77	3·80
Sulphates ... ... (SO_4)	none	none	none	0·40	none	none	none	5·43	none	none	none	none
Carbonates ... ... (CO_3)	56·16	77·72	82·49	91·53	105·78	87·32	69·27	62·21	57·28	49·67	51·11	53·37
Calcium ... ... (Ca)	11·68	10·55	12·10	11·52	12·52	11·92	11·52	21·06	13·91	10·33	12·28	11·48
Magnesium ... ... (Mg)	6·43	8·73	13·27	11·38	12·51	10·59	13·29	8·48	9·10	8·92	8·75	8·22
Potassium ... ... (K)	9·56*	—	22·01*	21·34*	20·73*	13·71*	15·16*	4·59*	9·18*	8·35*	8·47*	7·46*
Sodium ... ... (Na)	25·32*	—	34·00*	31·20*	37·03*	34·67*	22·22*	12·48*	16·65*	12·77*	11·35*	10·32*
Silica ... ... (SiO_2)	20·40	—	18·40	32·00	33·60	48·00	49·20	6·40	23·60	38·00	28·00	14·40

* The proportions of K_2O and Na_2O to which these are equivalent have been erroneously stated at about twice their value in a recent publication of the Survey Department of Egypt, "The Chemistry of the River Nile." The analytical data were furnished that Department in advance of the present publication.

[1] Contained Blue Nile water. *See page* 391.

WHITE NILE, 1907

	January	February	March	April	May
Solids in suspension	86·20	70·10	58·60	52·00	77·60
Solids in solution	127·00	152·70	163·00	183·05	168·80
"Free" ammonia ... ...(NH_3)	0·019	0·005	0·006	0·005	0·006
"Albuminoid" ammonia ... ...(NH_3)	0·446	0·271	0·349	0·312	0·425
Oxygen consumed in 10 min. at 100° C ...	6·51	5·64	5·23	5·41	4·89
Nitrates ... ... (N)	0·029	0·066	0·024	0·030	0·046
Nitrites ... ... (N)	none	none	none	none	none
Chlorides ... ... (Cl)	4·67	6·61	7·78	9·67	11·47
Sulphates ... ... (SO_4)	none	none	none	trace	none
Carbonates ... ... (CO_3)	58·23	72·76	84·61	94·16	84·80
Calcium ... ... (Ca)	12·12	15·32	14·90	14·92	7·98
Magnesium ... ... (Mg)	7·35	8·57	12·32	12·19	10·67
Potassium .. .. (K)	6·70*	9·15*	12·03*	—	17·47*
Sodium ... ... (Na)	19·27*	27·33*	29·63*	--	28·37*
Silica ... .(SiO_2)	28·00	10·40	12·40	—	7·30

BLUE NILE, 1907

	January	February	March	April	May
Solids in suspension	2·40	4·75	4·00	11·00	4·80
Solids in solution	120·00	136·85	128·80	130·55	153·60
"Free" ammonia ... ...(NH_3)	0·010	0·006	0·008	0·006	0·004
"Albuminoid" ammonia ... ...(NH_3)	0·056	0·115	0·222	0·220	0·150
Oxygen consumed in 10 min. at 100° C ...	1·98	2·11	2·16	2·66	2·40
Nitrates ... ... (N)	0·049	0·018	0·031	0·034	0·023
Nitrites ... ... (N)	none	none	none	none	none
Chlorides ... ... (Cl)	1·95	2·14	2·14	3·34	3·82
Sulphates ... ... (SO_4)	7·73	7·57	5·97	6·23	3·92
Carbonates ... ... (CO_3)	50·28	57·26	61·38	50·24	68·28
Calcium ... ... (Ca)	17·88	22·36	23·60	24·13	23·56
Magnesium ... ... (Mg)	7·26	6·99	8·83	8·20	11·81
Potassium ... ... (K)	1·43*	1·40*	1·29*	—	1·64*
Sodium ... ... (Na)	6·02*	8·85*	8·20*	—	15·7*
Silica ... ... (SiO_2)	10·80	10·40	13·60	—	10·40

* The proportions of K_2O and Na_2O to which these are equivalent have been erroneously stated at about twice their value in a recent publication of the Survey Department of Egypt, "The Chemistry of the River Nile." The analytical data were furnished that Department in advance of the present publication.

Solid matter in suspension. The following are the figures, in detail, obtained for the year 1906.

	BLUE NILE	WHITE NILE
	Parts per million	
January 15th	7·9	61·5
February 26th	11·6	55·7
March 21st	5·9	49·8
April 1st	6·2	46·5
" 15th	9·4	51·6
May 1st	11·3	50·1
" 15th	47·3	48·1
" 24th	27·6	—
June 2nd	30·0	108·0
" 16th	160·0	70·0
" 23rd	370·0	72·0
" 30th	522·0	74·7
July 14th	1216·0	52·4
" 21st	794·0	45·7
" 28th	1002·0	42·2
August 4th	3294·4	234·6
" 19th	1648·0	82·2
" 25th	949·6	185·0
September 1st	1364·0	109·2
" 8th	740·6	97·6
" 15th	744·0	59·0
" 22nd	416·0	46·7
" 29th	513·0	33·4
October 6th	439·0	22·6
" 13th	296·8	32·4
" 20th	209·6	—
" 27th	173·0	—
November 10th	151·6	—
" 24th	66·1	60·2
December 8th	26·8	—
" 23rd	17·2	48·2

It was evident that the cause of the high figure for suspended matter in the White Nile on August 4th was influx of water from the Blue Nile, the current of which was exceptionally high on that day. An attempt was made to take the sample from a point sufficiently far up the river to avoid error from this cause; but the proportion of sulphates and of potassium found shows that there was still a large proportion of Blue Nile water present. Omitting, in the calculation, the figure obtained on this date, the monthly averages become as follows:— Influx of Blue Nile water into White Nile

	BLUE NILE	WHITE NILE
	Parts per million	
January	7·9	61·5
February	11·6	55·7
March	5·9	49·8
April	7·8	49·0
May	28·7	49·1
June	270·5	81·2
July	1004·0	46·7
August	1964·0	133·6
September	755·5	69·2
October	279·6	27·5
November	108·8	60·2
December	22·0	48·2

The above results confirm the observations made in the Second Report as to the suspended matter carried by the White Nile—viz., that this is found in appreciable amount during the entire year, and that the water is never quite clear. As before, the lowest proportion was found in the latter part of September and the first half of October. This is obviously accounted for by the fact that during the period of flood of the Blue Nile the flow of the White Nile is impeded to such an extent that, south of Khartoum, the river is converted into an immense lake. As the result of this slowing-up of the current, the heavier particles settle and there is left in suspension only the finest clay-like material. Suspended matter in White Nile water

The cause of the different behaviours of the two Nile waters, and of their different appearance, has already been discussed (Second Report, *page* 210). It was shown that the Blue Nile was able, at certain seasons, to free itself of suspended matter, by reason of its higher content of calcium and magnesium salts and low proportion of alkali carbonates; and that the White Nile, on the contrary, remained "white" or turbid at all seasons as the result, on the one hand, of the presence of less calcium and magnesium salts, and, on the other, of a comparatively high proportion of alkali carbonates derived from the decomposition of the vegetable matter of the marshy regions. Even if allowed to stand, undisturbed, for a long time, White Nile water usually remains opalescent. Conditions influencing presence of suspended matter in the water of the Blue and White Niles

The above condition of affairs is true only of the White Nile, a considerable distance north of the Sudd region. But few samples from the south side of the Sudd region have been available, but it appears that the composition of the water above this point is appreciably different in several particulars from that of the Sudd region and below. Thus, in the series of analyses formerly reported, the sum of the potassium and sodium in the water collected at Bor was 37·5 parts per million. By the time the water had reached

Hillet Nuer, which is at about the centre of the marshy district, these two amounted to 53 parts per million (*see* table of analyses on *page* 393). Notwithstanding this high proportion of alkali (both exist as carbonates or bicarbonates), the tendency of which is to keep the clay and other finely divided matter in suspension, the water, at least on all the occasions on which observations have so far been made, is more or less clear, with floating particles. This effect is obviously due to the very large amount of organic matter, which has a flocculating effect on the suspended matter similar to that of calcium and magnesium compounds. (*See*, below, the note on the clarifying effect of iron in this connection.) It is interesting to note that as the river flows north, although the slope is slight and the stream therefore sluggish, the water gradually becomes more turbid. This effect is evidently due to the reassertion of the influence of the alkali carbonates; clay formed by the gradual decomposition of the material of the river bed and other finely divided matter are taken up, and the river again becomes "white."

Examination of White Nile water from various points

At the end of August, 1906, which was the termination of the rainy season, Mr. Goodson, on his return from Gondokoro, collected samples of the White Nile water at a number of points, and made observations on the appearance and behaviour of the water at the time. His notes were as follows:—

Gondokoro.—The water at this point contained considerable suspended matter of a reddish colour similar to that of the Blue Nile in flood, but much less in quantity. When this material had subsided the water remained opalescent from the presence of clay.

Bor.—Practically clear.

Shambe.—Water was practically clear when taken from the river, but soon turned yellow and a small amount of sediment was deposited.

Lake No.—Colourless and practically clear. A small amount of suspended matter was noted. This quickly settled and turned brown.

Kodok.—Similar to the water at Lake No, but was more yellowish and contained more suspended matter.

El Dueim.—Only slightly yellowish in colour. Clear, with a very few particles in suspension. These turned brown and settled quickly.

Geteina.—No longer clear. The water was distinctly opalescent from the presence of suspended clay, and had the usual appearance which characterises the White Nile water near Khartoum.

It is interesting to note that the clay was taken up when the river was moving so slowly that no appreciable current could be detected. At this season the White Nile is held up by the waters of the Blue Nile to such an extent that the river above Khartoum, and up and beyond El Dueim, has, as has already been noted, more the character of a lake than of a stream. The effect of the sodium and potassium carbonates in bringing into suspension the fine particles of clay, etc., is thus all the more clearly apparent.

Cause of clarification

The fact was noted that the water at Shambe was colourless when taken from the river, but that it became turbid and deposited a yellow sediment when exposed to the air. This is obviously due to the presence of a soluble salt or salts of iron, the existence of which in the ferrous condition was made possible by reason of the presence of the large amount of dissolved organic matter and consequent lack of oxygen. On exposure to air this iron becomes oxidised and deposited as ferric hydroxide, probably more or less combined with organic matter. There appears to be no doubt that the precipitation of this iron aids very materially in the clarification of the water which takes place between the Sudd region and Geteina.

Several samples of the water were collected at the time the above observations were made, with results as follows :—

White Nile water from the Sudd region collected during August and September

ANALYSES OF WATER FROM WHITE NILE IN SUDD REGION

Parts per Million

Number ...	517	518	519	520
Date of Collection	August 29th, 1906	August 30th, 1906	Sept. 2nd, 1906	Sept. 3rd, 1906
Solids in suspension...	134·5	4·20	5·32	12·78
Solids in solution	111·9	153·6	149·2	134·8
Oxygen consumed	7·54	8·27	6·65	8·21
" Free " ammonia	trace	n.d.	n.d.	n.d.
" Albuminoid " ammonia	·384	n.d.	n.d.	n.d.
Nitrates ... (N)	·077	n.d.	n.d.	n.d.
Chlorides ... (Cl)	6·05	8·13	4·91	7·37
Sulphates ... (SO_4)	2·79	none	none	none
Carbonates ... (CO_3)	51·22	71·50	60·12	53·16
Calcium ... (Ca)	8·34	12·32	15·10	11·12
Magnesium ... (Mg)	8·92	8·14	7·35	10·59
Sodium ... (Na)	20·68	24·27	20·34	18·00
Potassium ... (K)	3·75	7·65	3·75	5·85
Silica ... (SiO_2)	24·80	28·40	32·80	20·00

As the above samples were collected at the end of the rainy season, the water contained less matter in solution than is usually found. The following analyses of samples collected by Mr. Walsh, of the Sudan Irrigation Department, at a later season of the previous year (December, 1905), show a higher proportion of dissolved solids. The water was not seen until its arrival in Khartoum, so that the observations as to the appearance and behaviour of the water could not be made so satisfactorily as in the case of those recorded above.

White Nile water from the Sudd region collected in December

ANALYSES OF WATER FROM WHITE NILE IN SUDD REGION

Collected in December

Number...	307	308	309	310	311	312
Point of collection	Bor	Between Kenissa and Ghabe Shambe	Hillet Nuer	Down stream of Lake No	Between Taufikia and mouth of Sobat River	Kodok
Condition of water when sample arrived at Khartoum	Slightly opalescent. Faintly coloured. Slight sediment	Clear. Brownish. Slight sediment	Clear. Darker than No. 308. Dark brown sediment	Clear. Darker than 309. Dark brown sediment	Clear. Lighter in colour than No. 310. Slight sediment	Clear. Lighter in colour than No. 311. Slight sediment
Oxygen absorbed in 10 minutes at 100° C.	4·40	4·64	5·52	6·08	5·36	5·56
Chlorides ... (Cl)	7·74	7·18	7·50	8·88	3·59	5·48
Sulphates ... (SO_4)	1·12	none	none	none	none	none
Carbonates ... (CO_3)	58·56	59·93	67·46	74·96	55·41	49·47
Calcium ... (Ca)	9·74	9·74	9·34	10·53	9·74	10·18
Magnesium ... (Mg)	4·41	4·54	3·61	4·28	3·49	3·85
Sodium ... (Na)	24·32	25·83	35·59	30·29	12·70	23·45
Potassium ... (K)	13·21	15·30	17·39	17·56	7·48	11·21

Suspended matter in Blue Nile water

As in 1905, the Blue Nile was found practically clear during the months of January, February, March and April. As noted in the Second Report, the suspended matter found during these months is probably largely due to material blown into the river by the high winds which are so frequent during this season. During the flood season a much more complete series of determinations of the suspended matter was made than was done for the previous year. The highest monthly average was for August (1964 parts per million), and largest quantity found was on August 4th, when the figure rose to 3294 parts per million.

No sulphates in White Nile water

Absence of sulphates from White Nile water.—No sulphates were found in the water of the White Nile during 1906, except in the single case of the sample collected on August 4th, which evidently contained a considerable proportion of water of the Blue Nile, which, during its greatest height, flowed up the White Nile for some distance. The cause of the absence of sulphates from White Nile water is discussed in the Second Report of these Laboratories, *page* 211.

Tributaries of the White Nile

Examination of water from the tributaries of the White Nile

A few isolated analyses were made of water from the Nile tributaries. The following two samples from the Pibor[1] and the Baro[1] Rivers were collected by the Irrigation Department in January, 1906. That from the Baro River was taken near the junction (just upstream) of the Pibor. The figures express parts per million.

	PIBOR R.	BARO R.
Solids in solution	116·08	84·00
Oxygen consumed at 100° C. in 10 min. (O)	4·20	2·00
Chlorides ... ... (Cl)	1·89	1·70
Sulphates ... ... (SO_4)	none	2·81
Carbonates ... ... (CO_3)	37·15	26·65
Calcium ... ... (Ca)	13·91	9·14
Magnesium .. .. (Mg)	9·43	6·95
Sodium... ... ... (Na)	11·34	2·87
Potassium ... ... (K)	4·17	1·80

We are indebted to the Director of Steamers and Boats for the following interesting samples which were collected, in the heart of the Bahr-El-Ghazal region, from the Namtilla and Bushari Rivers, which join to form the Jur. These waters were of very unusual composition, the result of peculiar and exceptional conditions. Complete analyses could not be made, and the results are only approximate, as there was not sufficient of the water available for the purpose.

	NAMTILLA	BUSHARI
Reaction	slightly alkaline	acid
Total solids on evap. to dryness	97·00	112·00
Nitrates ... ... (N)	0·19	0·15
Chlorides ... ... (Cl)	none	none
Sulphates ... ... (SO_4)	none	none
Carbonates ... ... (CO_3)	9·25	none
Calcium ... ... (Ca)	3·38	5·00
Magnesium ... ... (Mg)	3·41	3·85
Sodium ... ... (Na)	2·29	2·36
Potassium .. .. (K)	0·98	2·58
Silica.. ... ... (SiO_2)	52·80	64·80

[1] These empty into the Sobat River.

These waters both contained iron and alumina in considerable quantity, but, as noted above, the samples were too small to determine their amount with accuracy.

Atbara River Water

The Atbara, like the Blue Nile, is a torrential river fed by the rains of Abyssinia, and the deposit from its muddy waters have played a very considerable part in the formation of Egypt. The river flows only for about three months and is dry for the remainder of the year, except for many pools, which are often deep.

Examination of the water of the Atbara River

During the flood season of 1907, examinations, especially with a view to determine the amount of suspended matter, were made at intervals of about a week. The results will be found in the following table.

The samples in each case were the average of six different collections taken at points roughly equidistant, across the river, as it flowed beneath the Atbara bridge. The figures express parts per million :—

RESULTS OF EXAMINATION OF THE WATER OF ATBARA RIVER

Flood Season of 1907

Date of collection	Solid matter in suspension	Carbonates (CO_3)	Chlorides (Cl)
June 27th...	4	not det.	not det.
July 4th...	16	72·52	4·34
„ 14th	1464	74·04	2·23
„ 18th	1623	60·43	3·51
„ 25th	3576	76·96	2·55
Aug. 2nd	2214	67·71	1·91
„ 12th	2040	71·82	2·55
„ 15th	3096	74·35	2·87
„ 22nd	2840	73·72	4·34
„ 30th	952	70·24	3·19
Sept. 6th	1314	71·19	3·82
„ 12th	1135	70·24	1·91
„ 19th	714	65·81	4·34
„ 30th	168	77·83	1·91
Oct. 3rd	176	79·10	2·55
„ 10th	30	83·62	2·87

Sulphates were present only in very minute quantity, amounting usually to less than one part per million.

The following table gives the monthly averages of suspended matter, as well as those of the Blue Nile, determined in 1906. It will be seen that during the height of the flood the proportion of solid matter carried was even greater than in the case of the Blue Nile.

Large quantity of suspended matter during flood

	ATBARA, 1907	BLUE NILE, 1906
June	4	270
July	1670	1004
August	2228	1964
September	832	755
October	103	280

Comparison of Atbara and Blue Nile waters

Laboratory Notes

Milk Supply of Khartoum

Analyses of Khartoum milk

In the Second Report of these Laboratories a note was made on the composition of the milk of cows of the Khartoum district, and also of that of goats. Attention was called to the fact that while in other countries the milk of goats was usually richer than that from cows, the same condition did not apparently hold for the Sudan. The few samples of cows' milk which it was possible to obtain up to that time were quite as rich as that from goats.

The average composition of the milk of goats examined and reported upon was:

Total solids	Fat	Solids not fat	
14·20	4·60	9·60	per cent.

Goats' milk and cows' milk compared

These figures are the average of four samples collected in October. The average of three samples of cows' milk collected at the same time was:

Total solids	Fat	Solids not fat
14·84	5·75	9·09

which indicated an appreciably greater richness in both total solids and fat.

It was not possible to obtain authentic samples of cows' milk for all the months in the year, but the following samples from a herd on the government farm, collected during the months of February, March and April, afforded results not materially different from those of the previous October. There is no indication, either in these figures nor in the experience of those who have had to do with the cows' milk of the Sudan, that there is any appreciable seasonal variation in the composition of milk such as obtains in other countries.

The yield of milk in hot countries is probably always less, but the milk is more concentrated.

Laboratory No.	Date of Collection	Total Solids	Fat	Solids not fat	Sp. Gr. at 60° F.
361	Feb. 14th	14·00	5·10	8·90	1033·0
394	March 12th	14·30	5·10	9·20	1032·0
395	,, 14th	14·45	4·90	9·55	1033·5
396	,, 17th	13·80	4·80	9·00	1031·5
397	,, 19th	15·40	5·80	9·60	1033·1
401	,, 24th	16·74	6·75	9·99	1034·0
404	,, 27th	15·10	5·60	9·50	1032·6
405	,, 29th	15·70	6·40	9·30	1031·7
407	,, 31st	14·18	5·10	9·08	1031·4
409	April 2nd	13·85	4·70	9·15	1031·9
411	,, 4th	15·00	5·65	9·35	1032·2
413	,, 8th	14·80	5·60	9·20	1031·7
414	,, 11th	13·80	4·70	9·10	1032·1
415	,, 14th	15·50	6·10	9·40	1032·4
416	,, 17th	13·85	4·80	9·05	1031·7
417	,, 19th	14·20	5·20	9·00	1031·1
418	,, 22nd	15·50	6·00	9·50	1032·6
420	,, 25th	15·00	5·80	9·20	1031·6
Average ...	... ...	14·72	5·45	9·27	1032·1

Adulteration of milk

Adulteration of milk, by addition of water, is still extensively practised; and as the water which may be used is anything but above suspicion the state of affairs is one which calls for remedy. The greatest danger lies in the want of cleanliness on the part of those who handle the milk, a matter with which it is obviously very difficult to deal in a native population such as this.

Poisonous Well Waters

Nitrates present in poisonous quantities in well water

It is not often that a well water, even though highly contaminated, is found to contain sufficient of any single mineral constituent to render it harmful. In Kordofan this appears to be not infrequently the case, especially towards the end of the dry season. One of these wells, near Nahud, was found to be distinctly poisonous to animals (the water, being known to be bad, was only used for animals and washing). A donkey, having drank of the water, was seized with severe colic, and died within twelve hours. A sheep was then given some of the water and died, suffering from the same symptoms, in an even shorter time. A sample of the water was then sent to the Laboratories by El Bimbashi Anderson, S.M.O., Kordofan District, with the history detailed above. On examination the explanation of the poisonous character of the water was found to be an exceedingly high proportion of nitrates. The quantity of the sample sent was too small to permit of complete analysis, but the determinations made were as follows:

Total solids	7656·0	parts per million
Nitrates (NO_3)	4428·6	,,
Chlorides (Cl)	513·5	,,
Sulphates (SO_4)	1298·0	,,
Carbonates (CO_3)	185·0	,,
Calcium (Ca)	814·9	,,

The nitrates are equivalent to 6·5 grammes of nitre per litre, or very nearly an ounce to the gallon. This is quite sufficient to account for the poisonous effect which was observed.

The smallest lethal dose of potassium nitrate recorded for an adult man is two drachms. This would be contained in a little over a quart of the water.

The water of another well in Kordofan—that near Gebel Schweih—which in November, 1907, contained a proportion of nitrates equivalent to 172 parts of potassium nitrate per million, was found in the following May, which is near the end of the dry season, to contain as much as 1204 parts per million, a proportion which is probably to be regarded as distinctly harmful.

Limestones and Lime

Limestones and lime

Good limestone for lime making is still lacking in many parts of the Sudan. In some localities the deposits of root-like masses and nodules are employed for the purpose, but sometimes with very unsatisfactory results. The attention of those employed in building operations should be called to the fact that, as a rule, such lime will give excellent results provided it be realised that it is not pure and the mixtures made with it are adjusted accordingly; *i.e.* that they will not permit of the addition of the usual amount of sand or *homra* (powdered burned brick).

On the average these limes contain, after slaking, about 50 per cent. of true slaked lime, and rarely as high as 60 per cent. If, therefore, this is allowed for by a lessened addition of sand or *homra* very good results will be secured.

Good crystalline deposit

An extensive deposit of good crystalline limestone has been found at Shereik, not far from Berber and close to the railway, and a special low rate of transport has been granted which will permit of its carriage to near-by points.

An analysis of a sample of the deposit gave results as follows:—

Calcium carbonate	90·02	per cent.
Magnesium carbonate	2·48	,,
Ferrous carbonate	1·70	,,
Insoluble in acid (quartz and mica)	6·01	,,
Total	100·21	,,

Lime from coral at Port Sudan

The coral formation on which Port Sudan is built produced a fat lime of good quality. The analysis of a sample furnished by Mr. C. E. Dupuis, Inspector-General, Sudan Irrigation Service, gave results as follows :—

Calcium carbonate	85·90 per cent.
Calcium sulphate	5·67 ,,
Magnesium carbonate	1·28 ,,
Ferric oxide and alumina	1·10 ,,
Silica	1·48 ,,
Water (free and combined)	3·96 ,,
Total	99·39 ,,

Deposits of gypsum

Gypsum Deposits. Red Sea Province

At the present time, the cost of plaster of Paris is so high in the Sudan that very little is used in building construction. The discovery of a deposit of gypsum at Gebel Tetawib, about one hundred miles north of Port Sudan, to which attention was called by Mr. C. Crossland, Marine Biologist, is therefore of interest. The deposit, which appears to be of considerable extent, is in some places at least 15 feet thick, and the outcrop is within a few hundred yards of a sheltered harbour.

Analysis of gypsum

Analyses of four samples of the rock were made, with results as follows :—

	Upper portion	Middle portion	Lower portion	Middle of S.W. end
Insoluble (silica, etc.)	0·89	1·70	0·64	0·72
Ferric oxide and alumina	0·36	0·48	0·40	0·40
Calcium carbonate	0·63	1·86	1·20	0·38
Sodium chloride	—	0·16	0·03	0·06
True gypsum (by difference)	98·12	95·80	97·73	98·44

Gypsum in masses of small crystals is also found in quantity a few miles south of the above, on the Rawaya peninsula. The composition of a single sample was as follows :—

Insoluble matter (sand, etc.)	1·15 per cent.
Ferric oxide and alumina	0·34 ,,
Calcium carbonate	1·53 ,,
Sodium chloride	2·55 ,,
True gypsum (by difference)	94·43 ,,

Either of the above deposits would furnish, if properly treated, a plaster of Paris of good quality.

Water from Deep Wells at Khartoum

The following are some results of examinations of a water from deep wells at Burrè, the eastern end of Khartoum. These wells were intended to be used as a source of the town water-supply, but, as will be seen, the water in its present untreated state is not suitable for the purpose. The wells in question were sunk to a depth of about 75 metres (one of them to 100 metres), but were only tubed to a depth of about 22 metres. Deep well water in Khartoum

A number of analyses of the water were made, but, as the variations were slight, the two following will suffice to show its character.

The figures are in parts per million.

Date of collection	Jan. 1st, '08	Jan. 11th, '08
Length of continuous pumping before sample was taken	About 2 days	About 5 days
Total solids by evap. to dryness	265·00	261·00
Free ammonia (NH_3)	0·55	0·62
"Albuminoid" ammonia (NH_3)	0·06	0·058
Oxygen consumed in 10 min. at 100° C.	2·00	2·00
Nitrites (N)	trace	trace
Nitrates (N)	0·10	0·06
Chlorides (Cl)	1·44	1·40
Sulphates (SO_4)	2·06	2·21
Carbonates (CO_3)	143·00	140·60
Manganese (Mn)	0·17	0·12
Iron (Fe)	1·33	1·22
Calcium (Ca)	64·31	64·80
Magnesium (Mg)	17·64	18·57
Potassium (K)	5·74	5·61
Sodium (Na)	7·88	8·02

Results of analysis of the Burrè water

In all cases the water was almost quite clear when it emerged from the pipe, but became distinctly opalescent after even a few minutes' exposure to the air and ultimately deposited a small amount of yellowish-red precipitate.

The taste of the water was faintly chalybeate. Its temperature was fairly constant at about 29° C.

The points specially to be noted in the above figures are the high proportion of free ammonia, and the presence of nitrites and of iron and manganese in considerable quantity.

Significance of high ammonia and nitrites

From the high temperature alone it appears evident that the water is, at least in great part, not the sub-soil water of the district, and that it, at some time in its history, was lying at a considerable depth. The high proportion of ammonia and the presence of nitrites do not necessarily, therefore, point to recent contamination. The existence, however, of iron and of manganese, the sum of which in the first sample amounted to 1·5 and in the second to 1·34 parts per million, is in itself sufficient to render the water unsuitable as a town supply. When the first sample of the water was tested it was predicted that *crenothrix*[1] would sooner or later develop in the pipes carrying it. This prediction was verified even sooner than was expected. At the end of a few weeks the iron pipes leading from the pump, and a thin iron plate over which the water passed, were found plentifully furred by the growth, its early appearance being probably due to the comparatively high temperature of the water.

Iron and manganese present

Growth of *crenothrix*

Cairo is, in part, supplied by a water similar to the above in several particulars; notably so in containing iron and manganese, the sum of which averages about 1·12 parts per million. This water has caused great dissatisfaction in use and a Commission appointed to study the question recommended the removal of the iron and manganese by aeration or chemical addition, followed by filtration. A similar treatment would be necessary in the case of the Khartoum water. It may be mentioned, in passing, that the bacterioscopic examination carried out by Dr. Balfour disclosed the water to be markedly contaminated, typical excretal *B. coli* having been found in so small a quantity as 0·02 c.c. Purification of this water must therefore be carried out, in any case, before it may be passed as potable.

Necessity for filtration

As regards the presence of iron and manganese it may be noted that these are probably to be expected in well waters of the deep or artesian class in Egypt and the Sudan. Besides the two cases just mentioned, iron (and probably manganese) is present in marked amount in the flowing wells of the Kharga oasis.[2]

The fluoresceïn test

The Detection of Well Pollution by the Use of Fluoresceïn

It was noted above that the water of the deep wells intended to supply Khartoum was found to be markedly contaminated. An attempt was made to determine the source of this contamination. An abandoned bore-hole containing impure sub-soil water and open to a depth of about 22 metres, which was suspected to be the cause of the trouble, was treated with a large amount of fluoresceïn and caustic soda and the water from the deep wells tested from time to time for a week, pumping being continuous for that time. No trace of fluoresceïn could be found. The water was in all cases evaporated to very small bulk (about one two-hundredth of the original) for the test. It was found that the concentrated water was so highly coloured that a satisfactory observation could not readily be made. The test was therefore modified as follows. From one to two litres of the water were evaporated to small bulk, a few drops of strong caustic soda solution added, and the

Modification of usual test

[1] *Crenothrix*, an aquatic plant which grows in water containing iron or manganese, causes an accumulation in the distributing pipes of a gelatinous, iron-bearing deposit, which seriously impedes and may even entirely stop the flow of water. Water affected in this way, besides being unsightly from the presence of long rusty filaments dislodged from the pipes, is unsuitable for laundry use, as it causes the linen to become iron-stained and corroded.

[2] Beadnell, "Flowing wells and sub-surface water in the Kharga Oasis." *Geographical Magazine*, Decade V., Vol. V., Nos. 524-525, February–March, 1908.

evaporation carried to dryness over the water bath. Five to ten c.c. of strong alcohol were then added, the dish heated on the bath and the alcohol brought in contact with all parts of the water-residue. The liquid was then passed through a small filter. The extraction with alcohol was repeated several times. As considerable alcohol is lost by evaporation the total volume of the several extractions did not exceed 10 c.c.

Delicacy of the test

So applied, the test was found to be much more delicate and satisfactory. In the absence of fluoresceïn, the alcohol remained perfectly colourless, and the addition of a minute trace of fluoresceïn to the original water was sufficient to impart a distinct fluorescence to the alcoholic extract.

Salt from Lugwâré Country

Analysis of sample of salt

The following is an analysis of a sample of salt collected in the Lugwâré country by El Bimbashi Mackenzie, S.M.O. Khartoum District.

The salt is said to be extracted from the ashes of a burned grass.

Moisture and organic matter	7·58	per cent.
Mineral matter insoluble in water	2·18	,,
Sodium sulphate	60·60	,,
Magnesium sulphate	5·40	,,
Potassium choloride	1·27	,,
Undetermined	1·24	,,
True salt (sodium chloride)	21·73	,,

Chemical Composition of some Sudan Grains

Sudan grains

The results of a number of analyses of Sudan grains are given in the following tables. (*See pages* 402–411.) For readier reference these include the several analyses made and reported previously. Dura, in its numerous varieties, forms the principal part of this series.

Method of examination

Attention is especially called to the collection of this grain from the "Gezira" by Mr. Davie, of the Department of Agriculture and Lands, and the very useful observations made by him in their connection. These samples are marked "W.A.D." The methods of analysis were, briefly, as follows :—

Moisture was determined by drying in an air oven at about 100° C.

Fat, by extraction of the dried sample with anhydrous ether in the Soxhlet apparatus.

Albuminoids, by calculation from the total nitrogen determined by the Kjeldahl-Gunning method, the factor employed being 6·25 or (in the case of wheat) 5·68. In some cases the albuminoids were also determined by precipitation by cupric hydroxide (Stutzer's method). Usually practically all the nitrogen in these grains exists as albuminoids.

Non-nitrogenous extract was determined by difference, the figure for albuminoids being that calculated from the total nitrogen.

Crude fibre was determined by the conventional method, which consists in boiling the ether-extracted material successively with 1·25 per cent. sulphuric acid and 1·25 per cent. sodium hydroxide solutions. The digestions were performed in the simplified apparatus figured and described in the Second Report of these Laboratories.

Ash was determined by incineration at a low temperature over the spirit flame.

Analyses of great millet (dura)

ANDROPOGON SORGHUM (SORGHUM VULGARE)

English—Great millet *Vernacular*—Dura

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Weight of 100 grains in grammes	
618	W.A.D.	"FATERITA" (White) ... ... *From* Edeid Abu Ushur	5·56	2·99	13·31	2·02	74·07	2·05	2·12	3·344	Yield 2·27 ardebs per feddan. Wt. per kela, 25·5 rotls. Suffered from want of water
1103	C.E.B.	"FATERITA" ... ... *From* Goz Abu Goma, White Nile	5·60	2·69	16·11	1·97	71·63	2·00	2·57	3·155	
201	—	"FATERITA" (White) ... .. *From* near Kamlin	6·20	3·02	12·31	1·80	74·57	2·10	1·97	3·600	
202	—	"FATERITA" (Red) .. . *From* Goz Abu Goma	4·90	3·00	14·18	2·10	73·77	2·05	2·36	3·787	
203	—	"FATERITA" (Brown) ... ... *From* Singa	6·17	2·77	8·93	1·72	78·67	1·67	1·42	3·567	Grows largely in heavy rain districts around Singa. Resembles *Faterita towil*. Grown largely in same locality, but the methods of growth are quite different and the two are easily distinguished
619	W.A.D.	"WADAKR" ... . *From* near Singa, 1906	5·39	2·41	13·69	2·13	74·73	1·65	2·19	2·748	
1110	C.E.B.	"WADAKR" ... . *From* Singa, 1908	4·78	2·55	14·06	1·79	75·05	1·77	—	2·692	
620	W.A.D.	"SEMSEM AHMAR" ... .. *From* Singa	4·77	5·83	16·36	3·03	67·44	2·57	2·61	2·130	Only a few heads are found. Not used for *kissera*,[1] but is washed and eaten uncooked
621	W.A.D.	"SEMSEM ABYAD" ... ... *From* Singa	5·66	4·19	16·09	1·81	69·92	2·33	2·57	3·146	Not used for *kissera*. Is washed and eaten uncooked. Found only in small quantity
622	W.A.D.	"HEGEIRI AHMAR" ... ... *From* between Sennar and Singa	6·05	3·60	13·64	1·95	73·47	1·89	2·08	4·061	Found in districts of heavy rain. Not grown as a special crop. Occasional heads appear in a crop of *Wadakr* or *Wad Massanet*
1108	C.E.B.	"HEGEIRI" ... . *From* Singa	4·55	3·18	15·01	1·95	73·43	1·88	—	3·267	
623	W.A.D.	"WAD EL FAHL" ... ... *From* Abu Ushur, near Kamlin	7·83	3·30	15·42	2·78	68·80	1·87	2·46	5·686	A heavy-yielding dura of good quality. Requires much water. Grown on sakieh land and on river flats
1105	C.E.B.	"WAD EL FAHL" ... ... *From* Goz Abu Goma	5·19	3·04	15·62	2·24	71·73	2·18	—	4·636	
624	W.A.D.	"FEKI MUSTAHI" or "SHEM FEKI" *From* Abu Ushur	10·82	3·49	12·95	2·97	68·13	1·64	2·07	4·213	Yield heavy. Very good quality. Grown on sakieh land and on river flats
625	W.A.D.	"MIKADO," "SHEL SHELLY".. *From* Eneikleiba	6·07	3·83	17·33	2·01	68·71	2·05	2·77	3·967	Said to come from Abyssinia. Not found in any quantity. Grows very tall
626	W.A.D.	"ZIRI ZERA," "ABD EL HER"... *From* Moya	6·20	3·33	12·87	2·74	73·23	1·63	2·06	1·942	Resembles *Hegari dura*, of good quality. Characterised by small-sized grains

[1] *Kissera*—Native bread; a sort of girdle cake.

ANDROPOGON SORGHUM (*continued*).

Analyses of great millet (dura)

Laboratory	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Weight of 100 grains in grammes	
627	W.A.D.	"GASSABI" ... .. *From* Edid Abu Ushur	5·64	3·12	13·83	2·36	73·07	1·98	2·21	2·818	Yield 1·82 ardebs per feddan. Requires more water than *Faterita* grain, much whiter than *Faterita*, and of good quality. Favourite species for *kissra*
1111	C.E.B.	"GASSABI" ... ... *From* Messellemia	4·36	2·80	16·32	2·23	72·14	2·15	—	2·949	
628	W.A.D.	"BAID EL WARRAL" .. *From* Eneikleiba	6·60	2·77	13·59	2·24	72·83	1·97	2·17	4·388	Tall. White grain of good quality. Requires good rains
629	W.A.D.	"WAD MASSANET"... *From* near Singa	5·70	2·85	12·93	2·74	73·97	1·81	2·07	4·335	Grown in heavy rain district. Stands much rain
630	W.A.D.	"HAKARIG" ... .. *From* Sennar	5·44	2·80	13·22	2·22	74·58	1·74	2·11	4·280	Requires good rains. Found in considerable quantity among the more common kinds in Sennar Province
631	W.A.D.	"HAKARIG" ... .. *From* Monagil	5·72	2·83	14·19	2·71	72·58	1·74	2·27	4·250	Much brighter in colour than sample obtained from South, where the rains were much heavier. Resembles *Hegeiri ahmar*
1104	C.E.B.	"HAKARIG" ... ... *From* Goz Abu Goma	5·05	2·57	14·36	2·19	70·91	1·92	—	3·517	
632	W.A.D.	"HEGEIRI" ... .. *From* Monagil	5·82	3·29	12·80	2·27	73·93	1·89	2·04	3·635	Grown in considerable quantity on low grounds of the rain terrace. Good quality
1108	C.E.B.	"HEGEIRI" ... ... *From* Singa	4·55	3·18	15·01	1·95	73·43	1·88	—	3·267	
1106	C.E.B.	"SAFRA, BAHR EL ABYAD" ... .. *From* Geteina	5·64	3·13	10·39	2·34	76·59	1·91	-	4·772	
1109	C.E.B.	"HAMAIZI" ... ... *From* Rufaa	4·55	3·21	17·22	2·34	70·68	2·00	—	3·918	

Notwithstanding the fact that many varieties of dura are grown in the Sudan, a considerable amount has been imported from India for consumption by Indians and others along the Red Sea Coast. This importation appears to be more or less steadily decreasing, and will doubtless before long cease altogether, native-grown grain taking its place. The following analyses of two samples of Indian dura, and of several Sudan duras approaching them in appearance and quality, are of interest in this connection.

It will be seen that all the grains are of the light yellow, wax-like variety, and that they contain proportions of oil appreciably above the average. It has been noticed that the duras most esteemed by the Sudanese invariably contain a high proportion of oil.

Comparison of Indian duras with certain Sudan duras. Analyses of pigeon pea and chick pea

A COMPARISON OF INDIAN DURA, IMPORTED INTO THE SUDAN, WITH CERTAIN SUDAN DURAS OF SIMILAR APPEARANCE

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Weight of 100 grains in grammes	Appearance of grain.
735	C.E.B.	Indian dura. Imported into Suakin	4·95	4·17	12·12	2·03	74·93	1·80	1·93	3·161	Light yellow. Waxy appearance
758	C.E.B.	Indian dura. ... ... *From* Jeddah	4·45	3·65	10·01	2·85	77·03	2·01	1·60	2·668	,, ,, ,, ,,
623	W.A.D.	"WAD EL FAHIL"... *From* Sudan	7·83	3·30	15·42	2·78	68·80	1·87	2·46	5·686	,, ,, ,, ,, See "remarks" on pages 402, 403
624	W.A.D.	"FEKI MUSTAHI"... *From* Sudan	10·82	3·49	12·95	2·97	68·13	1·64	2·07	4·213	,, ,, ,, ,, See "remarks" on pages 402, 403
632	W.A.D.	"HEGEIRI" ... ... *From* Monagil. Sudan	5·82	3·29	12·80	2·27	73·93	1·89	2·04	2·635	,, ,, ,, ,, See "remarks" on pages 402, 403

CAJANUS INDICUS

English—Pigeon Pea *Vernacular*—Ads Sudani

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes
178	J.J.A.	Seed unknown ...	6·20	1·37	21·63	n.d.	6·40	61·80	3·60	3·46	n.d.	9·986
920	A. & L.	,, ...	4·61	1·19	20·01	19·19	6·34	63·15	3·70	3·36	3·07	10·040

CICER ARIETINUM

English—Chick Pea *Vernacular*—Hommos

Laboratory No.	Collected by		Moisture.	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
921	A. & L.	—	4·52	4·19	24·62	23·14	3·48	60·03	3·16	3·93	3·70	12·798	Bought in Omdurman market

Analyses of small millet (telebun), barley, lentil and lupines

ELEUSINE CORACANA

English—Apparently unnamed. A small variety of millet — *Vernacular*—Telebun

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Weight of 100 grains in grammes
239	S.O.S.	From Wau, Bahr-El-Ghazal Province	7·35	1·25	5·28	2·85	81·26	2·01	0·84	0·215

HORDEUM SATIVUM

English—Barley — *Vernacular*—Shair

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
484	W.A.D.	—	7·11	1·62	17·83	n.d.	5·64	64·45	3·35	2·85	n.d.	4·255	Grown at Experimental Farm 1905-6

LENS ESCULENTA

English—Lentil — *Vernacular*—Ads

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes
177	J.J.A.	Grown in Egypt ...	6·22	0·96	27·30	n.d.	5·12	57·40	3·00	4·36	n.d.	2·864
918	A. & L.	,, ,, ,,	4·75	1·09	27·94	23·05	3·85	59·14	3·23	4·47	3·69	2·905

LUPINUS ALBUS

English—Lupine — *Vernacular*—Termis

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes
926	A. & L.	—	3·22	8·21	38·94	37·84	8·41	38·17	3·05	6·23	6·05	33·66

Analyses of rice, bulrush millet (dukhn), pea and small millet (teff)

ORYZA SATIVA

English—Rice | *Vernacular*—Ruz

Whole Seed, with Husks			Analysis of Seeds without Husks						
Weight of 100 seeds with husks	Per cent. of seed	Per cent. of husks	Moisture	Oil (Ether extract)	Albuminoids (Total N. × 6·25)	Non-nitrogenous extract	Crude fibre	Ash	Wt. of 100 seeds in grammes
3·71 grammes	81·03	19·97	6·30	2·52	10·60	78·31	0·86	1·41	2·488

PENNISETUM TYPHOIDEUM

English—Bulrush millet | *Vernacular*—Dukhn

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
297	W.B.	Kordofan	4·40	3·30	16·71	n.d.	3·55	70·49	1·51	2·67	n.d.	0·757	Bought in Omdurman market
316	S.O.S.	Kordofan	9·05	5·80	11·13	n.d.	2·75	68·98	2·29	1·78	n.d.	0·827	
915	A. & L.		5·33	5·47	16·90	16·90	1·56	68·11	2·66	2·70	2·70	0·808	Bought in Omdurman market

PISUM ARVENSE

English—Pea | *Vernacular*—Bissella

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
922	A. & L.	Seed unknown ...	4·72	1·29	22·24	n.d.	5·24	63·17	3·37	3·55	n.d.	18·919	Bought in Omdurman market

POA ABYSSINICA

English—Apparently unnamed. A very small variety of millet | *Vernacular*—Teff

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Weight of 100 grains in grammes
240	S.O.S.	*From* Kassala... ...	5·69	2·80	5·91	2·70	80·60	2·30	0·94	0·025

Analyses of fenugreek and wheat

TRIGONELLA FŒNUM GRÆCUM

English—Fenugreek | *Vernacular*—Helba

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
924	A. & L.	—	4·46	5·30	27·96	26·16	9·18	48·61	4·49	4·475	4·185	1·038	Bought in Omdurman market

TRITICUM SATIVUM

English—Wheat | *Vernacular*—Kamh

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 5·68)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
219	S.O.S.	Unknown seed ...	4·37	1·50	11·01	n.d.	2·90	77·74	2·48	1·93	n.d.	2·813	Bought in Omdurman market
220	A. & L.	From Indian seed ...	4·87	1·70	17·87	n.d.	3·40	69·66	2·50	3·14	n.d.	2·716	Reproduced at Experimental Farm for three years
221	A. & L.	Indian seed. *Mozaffarnagar*	4·50	1·58	14·83	n.d.	2·98	73·82	2·29	2·61	n.d.	2·795	Reproduced at Experimental Farm for two years
222	A. & L.	Egyptian seed ...	4·60	1·55	21·00	n.d.	3·35	69·20	2·30	3·69	n.d.	3·139	Reproduced at Experimental Farm for two years
223	A. & L.	So-called Sudan seed. Actual origin unknown, but probably Indian	4·95	1·70	21·53	n.d.	3·35	66·37	2·10	3·79	n.d.	2·465	Reproduced at Experimental Farm for two years
917	A. & L.	So-called Sudan seed	4·79	1·91	14·67	13·71	3·41	72·70	2·52	2·58	2·41	2·138	Bought in Omdurman market
916	A. & L.	So-called Egyptian seed	4·83	1·93	12·50	11·76	1·61	76·18	2·95	2·20	2·07	3·134	,, ,, ,, ,,
935	A. & L.	Indian seed	5·03	1·63	14·89	14·84	2·73	73·63	2·09	2·64	2·61	3·020	,, ,, ,, ,,
433	Gov. N.W. Province	Local (Dueim) seed	5·37	1·75	16·41	n.d.	2·66	71·87	1·94	2·89	—	2·468	Grown in mudirieh garden

Increase in nitrogenous constituents of certain foreign grains grown in the Sudan

In the course of the examination of certain grains grown from seeds obtained from other countries, it was noted that a considerable increase in the proportion of albuminoids resulted from planting in the Sudan. In order to test this effect in the case of wheat, a sample of Indian (Mozaffarnagar) seed was obtained in October, 1905, from Mr. Hughes, Chemist to the Khedivial Agricultural Society in Cairo. This was planted at the experimental farm at Halfaya, and the crop so obtained was again planted the following season.

The following are the results of analyses of the original seed and of the two successive crops.

The proportions of constituents, other than moisture, are calculated on the dry substance, in order to institute a more exact comparison.

C.L. No.	317	475	438
Seed	Original seed	1st crop, 1905-6	2nd crop, 1906-7
Moisture	8·00 per cent.	6·77 per cent.	5·45 per cent.
Ether extract	1·32	1·62	1·72
Albuminoids	11·63	14·81	14·76
Non-nitrogenous extract	82·08	78·20	77·22
Crude fibre	3·31	2·92	3·63
Ash	1·66	2·45	2·67
Total	100·00	100·00	100·00
Weight of 100 grains in grammes	2·713	2·709	2·676

As will be seen, there was an immediate gain in nitrogenous constituents. It would be absurd, of course, to generalise from such meagre data, but nevertheless it is interesting to note that the composition of the second crop is almost identical with that of the first. In other words, the alteration in composition resulting from the new environment appears to complete itself in the first planting; it does not take place gradually from year to year.

Climate more important than soil in determining composition of a wheat

From experiments of a similar nature conducted in America, it would appear that climate is the most important factor in determining the composition of a wheat, the soil having the least effect of all the important factors, always provided that the soil in question contains sufficient of the essential elements of plant food required for an average crop. The soil was found, however, to be a potent factor in the determination of the amount of material harvested, and, apparently, also the size of the grain.

Analyses of beans and maize

VICIA FABA

English—Bean *Vernacular*—Ful

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
931	A. & L.	—	3·94	1·24	31·42	n.d.	6·70	52·05	4·65	5·028	n.d.	41·402	Bought in Omdurman market

ZEA MAYS

English—Maize *Vernacular*—Dura Shami. Esh-El-Reif

Laboratory No.	Collected by	Seed	Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
200	S.O.S.	Seed unknown ...	4·97	5·17	13·02	n.d.	2·15	70·47	2·20	2·08	n.d.	17·37	Bought in Omdurman market
927	A. & L.	Egyptian ... ... Var. *Nab-El-Gamal*	4·48	5·21	14·86	12·07	2·19	71·34	2·01	2·377	1·931	24·866	
925	A. & L.	Egyptian ... ... Var. *Moradi*	4·59	5·11	12·19	11·96	1·98	74·57	1·56	1·95	1·91	22·75	
932	A. & L.	Native	5·45	4·57	12·07	11·71	1·89	74·29	1·73	1·93	1·87	15·805	

Oil seeds. Analyses of earth nuts, safflower and cotton

Oil Seeds

ARACHIS HYPOGÆA

English—Earth nut. Ground nut — *Vernacular*—Ful Sudani

Laboratory No.	Collected by	Source	Husk, per cent.	Kernel, per cent.	Oil, per cent. of kernel	Oil, per cent. of nut	Albuminoids (Tot. N × 6·25)	Ash	Weight of 100 nuts in grammes
639	W.A.D.	Kamlin	17·4	82·6	42·15	32·79	n.d.	n.d.	118·0
676	—	Gezira	21·14	78·86	46·63	35·1	n.d.	n.d.	112·0
933	A.L.	Omdurman market ...	18·69	81·33	47·91	38·94	22·52	3·02	73·6

CARTHAMUS TINCTORIUS

English—Safflower — *Vernacular*—Kurtum

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
929	A. & C.	—	1·89	29·47	20·34	19·16	22·58	22·78	2·94	3·255	3·066	4·502	Per cent. of oil in kernel = 48·62

GOSSYPIUM BARBADENSE

English—Cotton — *Vernacular*—Kutn

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen
432	Gov. W.N.P.	Grown at Dueim	4·43	24·11	24·81	16·91	25·73	4·01	3·96
431	Gov. W.N.P.	Carver's Egyptian seed from which above was grown	4·14	25·07	19·31	18·74	28·41	4·33	3·08

Oil seeds. Analyses of castor oil seeds, of sesame and of native-made sesame cake

RICINUS COMMUNIS

English—Castor oil seeds *Vernacular*—Hurua. Khiruwi

No.	District	Tested by	Kernels, per cent.	Shells, per cent.	Oil in kernels, per cent.	Oil in entire seed, per cent.	Weight of 100 seeds in grammes
672	Khartoum ...		76·09	23·91	62·30	47·46	9.20
667	Bahr-El-Ghazal ...		76·88	23·12	60·71	46·35	10·80
I.I. 17853	,,	Imperial Institute	n.d.	n.d.	n.d.	44·00	n.d.
I.I. 15931	Red Sea Province...	,, ,,	,,	,,	,,	41·10	..
I.I. 15931	,, ,, ,,	,, ,,	,,	,,	,,	48·70	..
I.I. 19320	,, ,, ,,	,, ,,	,,	,,	,,	47·00	..
I.I. 18112	Kassala	,, ,,	,,	,,	,,	42·00	..

SESAMUM ORIENTALE

English—Sesame *Vernacular*—Simsim

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6.25)	Albuminoids (by Stutzer's method)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen	Albuminoid nitrogen	Weight of 100 grains in grammes	
928	A.L.	—	1·70	47·76	26·15	24·66	7·03	11·16	6·20	4·185	3·946	0·247	Bought in Omdurman market
635	W.A.D.	—	2·89	46·55	32·31	n.d.	4·83	7·03	6·39	5·17	n.d.	0·256	Grown in Gezira district
636	W.A.D.	—	2·95	48·61	29·82	n.d.	4·34	9·26	5·02	4·77	n.d.	0·356	.. ..

The native-made sesame cake from the samples of seed Nos. 635 and 636 had the following composition:—

Laboratory No.	Collected by		Moisture	Oil	Albuminoids (Tot. N × 6·25)	Crude fibre	Non-nitrog. extract	Ash	Total nitrogen
637	W.A.D.	Made from No. 635	5·75	13·45	46·93	5·58	14·72	13·57	7·50
638	W.A.D.	Made from No. 636	6·25	14·41	47·99	6·50	14·69	10·16	7·67

Sudan fats and oils

Some Sudan Fats and Oils

BALANITES ÆGYPTIACA. Heglig—*Arab*

The fruit of this tree is bitter sweet and is eaten by the natives. It is of about the size and general appearance of a dried date and consists of a thin brittle shell enclosing a mass of gummy consistence surrounding and firmly adherent to the stone. The latter is very hard and tough and contains an oily kernel. The average weight of the fruit is about 7·5 grammes.

Heglig fruit

The proportion of outer shell	=	18·95 per cent. of the fruit	
,, ,, of dry pulp	=	30·58 ,, ,,	
,, ,, of nut	=	50·47 ,, ,,	
,, ,, of kernel	=	9·5 ,, ,,	
,, ,, of oil	=	4·14 per cent. of the fruit	
		8·21 ,, ,, nut	
		43·57 ,, ,, kernel	

The oil is highly prized by the natives and would be extracted on a much larger scale were it not for the very great difficulty which is experienced in separating the kernel from the tough, hard nut.

Chemical examination of the oil gave results as follows:—

Sp. Gr. at $\frac{100^\circ}{100^\circ}$ C.	=	·88919
Saponification value	=	186·5
Iodine absorption	=	99·2
Melting point about		8° C.

Elaidin test. Forms a buttery mass which separates from a liquid portion

No reaction to Becchi's, Baudoin's nor Halphen's test.

OIL OF BUTYROSPERMUM PARKII. SHEA BUTTER. *Vernacular*—Lulu

Shea butter

This oil, obtained from the seeds of the *Butyrospermum parkii*, is known in Europe under the names of "Shea butter" and "Galam butter." Considerable quantities have been imported into Europe from West Africa. The crude oil, as extracted by the native, is principally used in Europe, for candle and soap-making. The refined oil is employed in the manufacture of oleo-margarine and similar products.

The following are the results of examination of two samples of the oil from the Bahr-El-Ghazal Province. Both of these were of rather dirty appearance and dark colour, but were readily purified by heating with a small amount of animal charcoal, followed by filtration, both taste and colour being improved to a marked extent.

Laboratory Number	Acid value (milligrams KHO per gramme of fat)	Saponification value	Iodine value	Titer test	Sp. Gr. $\frac{100^\circ}{50^\circ}$ C.
400	11·2	180·9	56·08	49·6	862·0
634	9·9	182·0	55·50	51·2	861·0

These figures are in general agreement with those yielded by "Shea butter" from other localities.

A sample of the seeds of *Butyrospermum parkii*, from the Bahr-El-Ghazal Province, was examined with the following results:—

Kernel, per cent. of seed	Husk, per cent. of seed	Fat, per cent. of kernel	Fat, per cent. of seed	Weight of 100 seeds in grammes
69·06	30·94	57·00	39·37	355

These figures show a higher proportion of fat than those recorded for seeds from other localities; thus, Lewkowitsch states it as ranging between 49 and 52 per cent., and Mr. Edie informs me that in two samples of West African seeds he found 51·5 and 53·5 per cent. (of the kernel) respectively.

It is quite possible that the higher proportion found in the Sudan seeds was due to their having been exposed to the dry air of Khartoum for several months before they were tested.

OIL OF LOPHIRA ALATA. *Vernacular*—Zawa

This oil is obtained by the natives of Southern Sudan from the seeds of *Lophira alata*, which is indigenous also to Senegambia and Sierra Leone. The crude fat as extracted by the natives of West Africa is known as "Meni oil" or "Niam fat." The latter term would seem to be preferable in Europe, since the melting point of the oil is rather high. At ordinary temperatures it is a soft buttery mass, but in the higher temperature of the Sudan it is nearly always a clear liquid. As extracted by the crude, native, method, it is of dark colour and rather unpleasant taste, due to the presence, among other impurities, of a small quantity of resinous matter. The addition of a small amount of animal charcoal to the heated, crude, oil, followed by filtration, was found to result in such a marked improvement that this method of treatment was carried out before the determination of the constants was made. Such treatment is all the more indicated since there is little possibility of the oils being extracted in quantity in the Sudan, and that obtained by pressure from the seeds imported into Europe would be little likely to contain any considerable amount of resinous or unsaponifiable matter. Zawa oil

After the treatment mentioned, the oil was found to be of light amber colour and agreeable flavour, resembling that of freshly expressed arachis oil. Analysis of Zawa oil

The following constants were determined:—

Specific Gravity $\frac{100^\circ}{15^\circ}$ C. = 861·5	$\frac{40^\circ}{40^\circ}$ C = 906·4
Melting point, about	10·5° C.
Saponification value	177·1
Unsaponifiable matter in crude oil	0·78 per cent.
,, ,, in purified oil	0·67 ,,
Iodine value	72·7 ,,
Specific temperature reaction	139·4°
Elaidin test	remains liquid
Baudoin's test	no reaction
Halphen's test	no reaction

Results of examinations of the fruits of *Lophira alata* from Sierra Leone were reported by Edie,[1] and later by Lewkowitsch,[2] as follows:—

	Edie	Lewkowitsch
Seeds, per cent. of fruits	6·6	61·5
Oil, per cent. of seeds...	31·8	38·5
Oil in entire fruit	—	19·18[3]

Edie (*loc. cit.*) found that the ethereal extract from the kernels separated into (*a*) a dark brown brittle mass, and (*b*) a white fat containing, when purified by means of chloroform,

[1] *Journal of the Society of Chemical Industry* (1907), 1148.
[2] *Ibid.* (1907), 1265.
[3] Freed from resinous matter.

free acid equivalent to 1·5 c.c. of decinormal alkali per gramme of fat. The saponification value of the fat was 195, and the iodine value 75·3.

The free acid from the lead soaps insoluble in ether had the neutralisation value 195 and iodine value 22·5, whilst those from the insoluble lead soaps had the neutralisation value 196 and iodine value 134·5.

Lewkowitsch also found, in the ether-extracted samples examined by him, black resinous matter amounting to 0·8 per cent. of the weight of the seeds. His results on the samples extracted by ether from Sierra Leone seeds and from an Egyptian Sudan native-prepared sample, were as follows:

	Fat extracted from kernels	Fat prepared by natives of Sudan
Sp. Gr. at $\frac{40°}{40}$ C.	0·9105	0·9063
Acid value	18·54	5·78
Saponification value...	195·6	190·1
Unsaponifiable matter	1·49	1·38
Iodine value	68·4	78·12
Mean molecular weight of fatty acids ...	...	283·7
Titer test	...	42·5

Lewkowitsch gives the melting point of "Niam fat" as 24° C. The sample of Sudan oil tested by us had, as noted above, a much lower melting point—namely, about 10·5° C.

Ben oil

OIL OF MORINGA PTERYGOSPERMA. BEN OIL

Analysis of Ben oil

This oil is obtained from the seeds of the *Moringa pterygosperma*, which is found plentifully in the Sudan. The results of the chemical examination of a sample extracted from Sudan seeds are in general agreement with those of this oil from other sources.

Specific Gravity $\frac{15°}{15}$ C. = ...	·9125
Saponification value = ...	187·2
Iodine value	80·0
Begins to deposit crystals at	8° to 10° C.
Specific temperature reaction	80·7°

After separation of the "stearine" the liquid portion of this oil is used as a lubricator for delicate machinery (watches, etc.), by reason of its very slight liability to turn rancid on exposure.

Sudan gums

SUDAN GUMS

The principal gum exported by the Sudan is that from the *Acacia verek*, which is found chiefly in the Kordofan Province, though more or less extensive forests of the tree exist in the Gezira district (the land lying between the Blue and White Niles) and near Gedaref. The tree is known locally as the "hashab," and is said to be identical with the *Acacia senegal* from which Senegal gum is derived.

Hashab gum from *Acacia verek*

Since the report of 1906 was published, one has had an opportunity to visit the Kordofan gum forests and make a few observations as to the methods of working carried out by the natives. These differ in certain particulars from those noted by Muriel,[1] and a few notes on the subject may not be out of place.

Visit to Kordofan gum forests

There is perhaps no industry more poorly paid than gum collection, as at present

[1] "Report on the Forests of the Sudan," C. E. Muriel, 1901.

carried out. For this reason, the collector, who is above all an agriculturalist, makes the work of gum collection a secondary matter, and directs his attention primarily to the cultivation and harvesting of his crops—dukhn, sesame, dura, etc. These safely harvested, he is then willing to devote his time to the gum. It follows from this that while the trees are ready for tapping early in the autumn, by far the greater number are only tapped in January or February, so that the season of exudation, which ends early in May, has a duration of about four months. An attempt is now being made to determine the extent to which the quantity and quality of the gum are affected by the time of tapping and the length of season of exudation.

Tapping season

It has been stated by Muriel that Kordofan gum is of two sorts—one obtained from tapped trees in private geneinas (gardens), and known as "hashab geneina," and the other from wild, untapped trees, in unowned forests, and known as "hashab wady." At the present time there is little or no collection of "wady" gum, all the trees from which gum is gathered being under at least nominal ownership, and they are all tapped. The name "wady" is now often applied to any large tear of gum which may happen to be rather dark in colour. A small amount of gum is always found in the geneinas, exuding from natural cracks or fissures in the bark. This is not, strictly speaking, wady gum. It is collected along with the gum exuded at the points of tapping.

"Hashab geneina" and "Hashab wady"

Forests of hashab trees from which gum has never been collected are known to exist, but these are either in outlying districts, where there is no water during the dry season, or, if supplied with wells, the natives of the district are, as yet, unwilling to occupy themselves in the industry.

The working of the whole of the vast gum-producing district of Kordofan is dependent upon the existence of a very small number of wells. Geneinas situated within a reasonable distance of these are operated with comparative ease, but those further away only incompletely and with great difficulty. Those who gather the gum are forced to carry their water, food, and the collected gum with them; and as collections take place in the hottest and driest months of the year, it is not a matter of surprise that, in most cases, the workers will not go any further than their actual needs force them. Steps are now being taken to sink wells in suitable places in order to render new forests available and the old ones more accessible.

Necessity for more wells in gum districts

The trees are tapped at a convenient time, between October and February, after the cessation of the rains, the season of which usually extends from about the middle of June to the end of September. The method of tapping is shown in Fig. 205. It consists in cutting the bark with a small axe and tearing off a thin strip, which, as noted by Muriel *(loc. cit.)*, should apparently not be greater than 2 or 3 feet in length and 1 to 3 inches wide, depending upon the size of the branch operated upon. Care is usually taken that the incision does not penetrate into the wood, a thin layer of the inner bark being left to cover it.

Method of tapping

According to Muriel, some 60 days elapse after tapping before the first collection is made. It appears, however, that this would be the case only if the weather be exceptionally cold. The rate of exudation is found to be closely dependent upon the temperature. If the weather is very hot there may be sufficient gum exuded in a much shorter period, but it is allowed, in any case, to remain upon the tree at least two weeks in order that the tear may be fairly firm. If picked off too early the gum in the interior may be so liquid as to run out and leave only a hollow shell, which easily crushes in transit. The effect of heat on gum exudation is referred to again. (*See page* 420.)

Conditions influencing exudation

The total number of collections in a season is usually seven or eight.

Origin of Gum and the Conditions affecting its Production

Origin of gum

It must be borne in mind that the remarks below refer solely to the "hashab" tree. Even a superficial examination of the subject is sufficient to show clearly that, as regards gum production, every variety of tree is a law unto itself. This is readily explicable on the microbic theory of gum formation, since it is to be expected that different organisations should vary as to their ability to resist the attack of the microbe.

Conditions affecting its production

Soil

Soil. One of the conditions which have been noted by Muriel as apparently favourable to the production of gum is a ferruginous, sandy soil. Several samples of soil from Kordofan gum gardens have been collected and examined. It may be noted that, while reddish from the presence of iron, the actual amount present is nevertheless not so great as in most Sudan soils. The practical absence of organic matter renders such iron as is present more evident.

Analyses of soils from gum districts

Analyses of several of these soils were made. The following two were collected by Mr. A. F. Broun, Director of Woods and Forests. One was from a good gum-yielding geneina, and the other was apparently similar soil where hashab trees were absent.

Laboratory number	549	550
Description	Soil from good hashab geneina	Apparently similar soil. No hashab
Loss at 100° C.	0·094	0·038
Loss on ignition	0·082	0·075
Insoluble in hydrochloric acid	97·97	98·54
Carbonates (expressed as $CaCO_3$)	0·038	0·019
Nitrogen	0·046	0·041
Soluble in boiling hydrochloric acid		
Ferric oxide (Fe_2O_3)	0·60	0·47
Phosphates (P_2O_5)	0·012	0·011
Potash(K_2O)	0·052	0·048

Both of these are obviously extremely poor—what would usually be described as barren, sandy soils. The sample taken from the point where no hashab was found is slightly poorer, but the difference between the two is so slight that one must evidently look elsewhere for the cause of the absence of hashab growth.

The following are more complete results of examination of two samples of soil from a good geneina (that of Ali Nur-ed-Din) near Taiara. The first was taken from the surface and the second from a depth of about 10 feet. At the time of collection the deeper soil looked darker, but this was found to be due simply to moisture. After standing in the air both were of the same appearance—lightly red and sandy.

For the mechanical analyses the method described by H. D. Hall[1] was employed.

[1] *Journal of the Chemical Society*, 1904, p. 950.

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FIG. 204.—GUM GARDEN NEAR TAIARA, KORDOFAN

Analyses of surface soil and sub-soil from a good gum-yielding geneina :—

Description		—	Surface soil	Sub-soil at 10 ft. depth
Number		—	693	691
MECHANICAL ANALYSIS ...	Fine gravel...	... (3·0 to 1·0 mm. diameter)	—	—
	Coarse sand	... (1·0 to 0·2 ,, ,,)	—	0·02
	Fine sand ...	... (0·2 to 0·04 ,, ,,)	95·53	90·85
	Silt	... (0·04 to 0·01 ,, ,,)	0·66	0·87
	Fine silt ...	... (0·1 to 0·004 ,, ,,)	0·23	0·26
	Very fine silt	... (0·004 to 0·002 ,, ,,)	0·82	0·50
	Clay... ...	... (0·002 to — ,, ,,)	1·38	5·17
CHEMICAL ANALYSIS ...	Moisture ...		0·02	0·10
	Insoluble in hydrochloric acid		97·57	96·08
	Total nitrogen		0·036	0·014
	Nitrogen as nitrates		traces only	traces only
	Carbonates expressed as $CaCO_3$		0·031	0·036
	Extracted by boiling hydrochloric acid			
	Lime (CaO)		traces	0·132
	Magnesia (MgO)		0·099	0·126
	Potash (K_2O)		0·123	0·113
	Phosphoric acid (P_2O_5)		0·017	0·014
	Soluble in 1 per cent. citric acid			
	Available phosphoric acid (P_2O_5)		0·0025	0·0011
	Available potash (K_2O)		0·0181	0·0098

Examination was also made of a sample of soil from one of the depressions, hardly deep enough to be called valleys, where no hashab growth is found. This soil is always darker than that of the geneinas in which hashab thrives.

	Per cent.
Insoluble in acid	95·75
Nitrogen	0·041
Nitrogen as nitrates	0·001
Carbonates expressed as $CaCO_3$	0·091
Soluble in boiling hydrochloric acid	
Lime (CaO)	0·263
Magnesia (MgO)	0·995
Phosphoric acid (P_2O_5)	0·021
Potash (K_2O)	0·290
Soluble in 1 per cent. citric acid	
Available potash (K_2O)	0·018
,, phosphoric acid (P_2O_5)	0·002

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Fig. 205.—Tapping the Tree

Physical analysis of the sample could not be made, as it was lost in the recent fire which destroyed a portion of the Laboratories.

It will be noted, that while both lime and magnesia are present in these soils in but small amount, the proportion of the latter to the former is relatively great.

There is nothing in the figures just given to show why the soil in these depressions should not support hashab trees equally as well as the soil of the geneinas. It was thought that the explanation of their absence would be found in a higher proportion of soluble salts accumulated in the lower levels, but examination proved these to be practically absent.

In spite of the obvious poverty of "geneina" soils in Kordofan, it may be of interest to note that they are found to bear fair crops of millet, sesame, earthnuts, etc.

Moisture

Moisture. Hashab trees in soil well supplied with water during the dryer season fail completely to yield gum. In this respect these trees differ markedly, *e.g.* from *A. arabica* (sunt) trees, which by tapping may be made to yield gum, even when situated close to the river, with roots well supplied with moisture and the tree covered with green foliage.

The largest yield of gum seems to result from a good rainy season followed by one exceptionally hot and dry.

Protection from fire

Protection from fire. Experience has shown that the scorching of the trees resulting from a fire in the undergrowth renders a geneina unproductive for the season. This is quite in accordance with the bacterial explanations of gum production, the microbes being destroyed by the heat and the geneina more or less sterilised.

Tapping

Tapping. It has been noted that, in tapping, strips of 2 to 3 feet in length and 1 to 3 inches in width, more or less, according to the size of the branch operated upon, appear to give the best results. When longer strips, 6 feet or more, were torn off, less gum exuded, and there was the additional disadvantage that the tree was unnecessarily weakened. Injury due to injudicious barking is often very great. The workers have found that even when the usual method is employed the tree will not stand tapping more than once every alternate year. In order to determine whether the injury due to barking might not be lessened, the experiment was made of tapping by a number of short cuts without removal of the bark. By direction of the Director of Woods and Forests, Mr. Bisset, the Deputy Inspector of this district, also had a number of trees tapped by removing shorter strips of the bark than is the usual practice. The total yield of gum per tree for the entire season of collection is given in the table below, in which is included, for comparison, the average yield from small, medium-sized, and large trees in neighbouring gardens, tapped in the ordinary manner. The weights of gum are given in rotls, which may be taken roughly to equal pounds. (2·166 rotls = 1 kilogram.)

Garden of	Method of Tapping	Size of Tree	Average Yield of Gum per tree
Ali Nur-ed-Din ...	Ordinary	Small	0·75 rotl
	,, ...	Medium	1·33 ,,
,,	,, ...	Large	1·90 ,,
Feki Wad Bellal ...	Short strips	Smaller	0·52 ,,
,,	,, ...	Larger	0·87 ,,
Adam Afifi	Ordinary	Medium	0·90 ,,
,,	Numerous cuts without removal of bark	,, ...	0·28 ,,

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Fig. 206.—Exudation of Gum near point of Tapping

The trees in the garden of Adam Afifi were tapped rather later than the others. This may account to some extent for the lower yield by the ordinary method of tapping as compared with those in the garden of Ali Nur-ed-Din.

It appears evident from these figures that, at least as regards yield, the ordinary method of tapping offers a considerable advantage over that of simple gashing or the removal of shorter strips. Whether the life of the tree would be materially lengthened under the modified treatment could only be determined by long experience, starting with virgin trees. As regards the quality of the gum, it may be noted here that the chemical examination of these samples failed to show any decided improvement as resulting from the altered method of tapping.

Inoculation

Inoculation. In view of the results of Greig Smith's investigations, which appear to prove that gum is formed as the result of infection of the sap by a microbe resident presumably in the bark, and also that extensive removal of the bark is undesirable, an experiment was carried out as follows: Tapping was performed by making a series of gashes with an axe, no bark being stripped off, and (as the chances of efficient natural inoculation might thus be lessened) an attempt was made to ensure the entrance of the microbe by rubbing a moist rag over the bark and subsequently into the cut. A series of trees tapped in the native fashion (by stripping the bark) was treated in the same manner for comparison. The following table exhibits the results obtained.

Garden of	Number of trees operated upon	Size of trees	Method of tapping	Inoculated or not	Yield of gum per tree
Adam Afifi ...	25	Medium	Ordinary... ...	Not inoculated ...	0·9 rotl
,,	25	,, ...	,, ...	Inoculated ...	0·55 ,,
,,	25	,, ...	Short gashes ...	Not inoculated ...	0·28 ,,
,,	25	,, ...	,, ,, ...	Inoculated ...	0·14 ,,

This quite unlooked for result is not without significance of practical value. It goes to show that the yield of gum is affected to a very great extent by conditions other than the mere stripping of the bark. The explanation of the lower yield may be that inoculation takes place ordinarily by the microbes falling upon the sap which exudes in slight quantity when the bark is stripped off, and that when the water was rubbed over the bark and then into the cut the effect was rather to wash away this sap and render inoculation less complete and effective.

Effect of temperature

Effect of temperature. The above conclusions as to why the inoculation attempted was ineffective find support to a certain extent in experience as to the effect of cold *at the time of tapping.* According to the gum collectors, the trees should always be tapped on a warm day if a good yield of gum is to be secured. It is stated, further, that if the operation is performed on a cold day and several successive cold days follow, the tapping may be nearly or quite fruitless. This statement finds confirmation in the results of the following experiments:—

Garden of	Method of Tapping	Number of Trees	Temperature	Average yield per tree
Faki Wad Bellal ...	Ordinary. No inoculation	3	Hot day	1·30 rotls
,,	,, ,, ...	3	Cold day	0·63 ,,
,,	,, Attempted inoculation	3	Hot day	0·45 ,,
,,	,, ,, ,,	3	Cold day	0·16 ,,

Fig. 207.—Native Gum Collector

It is evident that cold at the time of tapping has a great retarding effect on gum production. It is possible that the growth of the microbe is inhibited by the low temperature and the wound has a chance to heal before effective infection has taken place.

Season of collection

Season of collection. Tabulated statements of some of the results obtained from the experimental tappings carried out during the season of 1906-1907 will be found in the following tables :—

GARDEN OF ALI NUR-ED-DIN, NEAR TAIARA

30 SMALL TREES

Tapped in the ordinary native manner, December 15th, 1906

Laboratory No.	Number of Collection	Date of Collection	Yield per tree	Character of Gum	Acidity (milligrams of KHO required to neutralise one gramme)	Ash of cleaned gum	Viscosity of 20 per cent. solution: Degrees of retardation in torsion viscosimeter	Viscosity of 20 per cent. solution: Grammes of sugar, per 100 c.c. of solution, required to produce same viscosity
759	1st	Jan. 17th, '07	0·134 rotl	Semi-glassy. Small pieces, but not powdery	3·14	2·96	40·5°	63·4
760	2nd	Feb. 4th, '07	0·216 rotl	Like 1st collection	2·74	2·96	31·5°	61·8
761	3rd	Feb. 15th, '07	0·134 rotl	Like 1st collection	2·55	2·86	31·0°	61·7
762	4th	Mar. 8th, '07	0·091 rotl	Like 1st collection	2·55	2·89	29·5°	61·3
763	5th	Mar. 22nd, '07	0·083 rotl	Slightly lighter in colour, more powdery	2·55	2·74	26·5°	60·7
887	6th	Apr. 7th, '07	0·058 rotl	Like 5th collection	2·16	2·88	24·5°	60·2
Not received at laboratory	7th	May 13th, '07	0·034 rotl	—	—	—	—	—

30 MIDDLE-SIZED TREES

Tapped in the ordinary native manner, December 15th, 1906

Laboratory No.	Number of Collection	Date of Collection	Yield per tree	Character of Gum	Acidity	Ash of cleaned gum	Degrees of retardation	Grammes of sugar
764	1st	Jan. 17th, '07	0·183 rotl	Light colour. Small fragments. Friable	2·94	2·99	ropy	—
765	2nd	Feb. 4th, '07	0·284 rotl	Darker colour. Larger tears ...	3·14	3·09	30·5	61·6
766	3rd	Feb. 15th, '07	0·266 rotl	Lighter in colour than former ...	2·74	2·84	33·7	62·2
767	4th	Mar. 8th, '07	0·225 rotl	Mostly glass-like. Fair-sized fragments	2·74	2·87	31·8	61·8
768	5th	Mar. 22nd, '07	0·175 rotl	Similar to 767	2·55	2·86	28·5	61·2
886	6th	Apr. 7th, '07	0·134 rotl	Mostly small fragments... ...	2·35	2·78	27·0	60·8
Not received at laboratory	7th	May 13th, '07	0·066 rotl	—	—	—	—	—

30 LARGE TREES

Tapped in the ordinary native manner, December 15th, 1906

Laboratory No.	Number of Collection	Date of Collection	Yield per tree	Character of Gum	Acidity	Ash of cleaned gum	Degrees of retardation	Grammes of sugar
769	1st	Jan. 17th, '07	0·233 rotl	Approximately the same as that from middle-sized trees	2·55	3·20	ropy	—
770	2nd	Feb. 4th, '07	0·53 rotl		2·74	3·10	38·7	63·0
771	3rd	Feb. 15th, '07	0·283 rotl		2·55	2·81	37·0	62·8
772	4th	Mar. 8th, '07	0·233 rotl		2·35	2·92	40·5	63·6
773	5th	Mar. 22nd, '07	0·300 rotl		2·35	3·01	34·5	62·3
885	6th	Apr. 7th, '07	0·192 rotl		2·16	2·74	26·9	60·7
Not received at laboratory.	7th	May 13th, '07	0·133 rotl	—	—	—	—	—

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Fig. 208.—Collector with Water-skin, Sack for Gum and Food, and Spear for Protection against Wild Animals

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Fig. 209.—Collection of Gum from Upper Branches

GARDEN OF FAKI WAD BELLAL

30 Smaller Trees

Tapped on January 4th, 1907, by removing smaller strips than is customary

Laboratory Number	Number of Collection	Date of Collection	Yield per tree	Character of Gum	Acidity (milligrams of KHO required to neutralise one gramme)	Ash	Viscosity of 20 per cent. solution: Degrees of retardation in torsion viscosimeter	Viscosity of 20 per cent. solution: Grammes of sugar per 100 c.c. of solution required to produce the same viscosity
774	1st	Feb. 25th, '07	0·133	Much white friable gum. Considerable small gum	2·35	3·24	38·2	63·0
775	2nd	Mar. 6th, '07	0·067	Nearly half-glassy. Much small gum	2·74	3·17	61·2	66·3
776	3rd	Mar. 18th, '07	0·116	Practically all white friable gum in fairly large tears	2·94	3·82	43·5	63·8
777	4th	Mar. 26th, '07	0·058	Like 776 but some glassy gum ...	2·94	2·92	43·5	63·8
778	5th	Apr. 6th, '07	0·067	Nearly half-glassy	3·34	3·13	33·2	62·1
854	6th	Apr. 25th, '07	0·042	About half of gum is glassy ...	2·55	2·81	34·5	62·3
855	7th	May 6th, '07	0·025	Like 854	2·74	2·81	29·5	61·3
856	8th	May 19th, '07	0·017	Practically all glassy gum ..	3·34	2·87	39·7	63·3

30 Larger Trees

Tapped on January 4th, 1907, by removing smaller strips than is customary

Laboratory Number	Number of Collection	Date of Collection	Yield per tree	Character of Gum	Acidity	Ash	Degrees of retardation	Grammes of sugar
779	1st	Feb. 25th, '07	0·167 rotl	Much friable gum. Considerable small gum	2·55	3·53	31·2	61·7
780	2nd	Mar. 6th, '07	0·133 rotl	Similar to 779	3·14	3·53	34·5	62·3
781	3rd	Mar. 18th, '07	0·200 rotl	Nearly all friable. Less small gum than 779	2·74	3·17	42·5	63·7
782	4th	Mar. 26th, '07	0·083 rotl		2·94	2·97	59·0	66·1
783	5th	Apr. 6th, '07	0·134 rotl	More glassy gum	3·14	2·84	29·7	61·4
851	6th	Apr. 28th, '07	0·075 rotl	Mostly glassy. Not much powder	2·74	2·98	28·0	61·0
852	7th	May 6th, '07	0·042 rotl	Mostly large pieces. Nearly all glassy	3·14	2·71	24·5	60·2
853	8th	May 19th, '07	0·033 rotl	Smaller pieces. Glassy	2·90	2·71	24·0	60·0

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Fig. 210.—Kordofan Sheik. Owner of Gum Garden

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Fig. 211.—Gum Dealer at Omdurman

GARDEN OF ADAM AFIFI

25 Medium-sized Trees

Tapped in the ordinary native manner, February 3rd, 1907

Laboratory Number	Number of Collection	Date of Collection	Yield per tree	Character of Gum	Acidity (milligrams of KHO required to neutralise one gramme)	Ash	Viscosity of 20 % solution: Degrees of retardation in torsion viscosimeter	Viscosity of 20 % solution: Grammes of sugar per 100 c.c. of solution required to produce the same viscosity
802	1st	Mar. 7th, '07	0·14 rotl	Considerable powdery gum ...	2·74	3·34	60·5	66·5
803	2nd	Mar. 16th, '07	0·24 rotl	More glassy and less powdery gum	2·94	3·11	42·2	63·7
804	3rd	Mar. 26th, '07	0·20 rotl	Like 803, but larger tears ...	3·34	3·11	37·2	62·8
805	4th	Apr. 4th, '07	0·14 rotl	Mostly soft white gum in fair-sized tears	3·14	3·09	33·0	62·1
869	5th	Apr. 13th, '07	0·12 rotl	Like 805, smaller pieces, but powdery	3·14	3·06	34·0	62·3
870	6th	Apr. 24th, '07	0·07 rotl	More glassy	2·74	3·09	28·5	61·2
871	7th	May 5th, '07	0·041 rotl	Like 870	2·94	2·76	25·0	60·3
872	8th	May 16th, '07	0·02 rotl	Like 870	2·74	2·89	22·5	59·6

Tapped in the native manner, February 3rd, 1907. Attempted inoculation. (*See page* 422)

806	1st	Mar. 7th, '07	0·07 rotl	Similar to the collections from uninoculated trees, but of appreciably lighter colour	2·55	3·35	62·7	66·5
807	2nd	Mar. 16th, '07	0·12 rotl		2·94	3·08	35·7	62·4
808	3rd	Mar. 26th, '07	0·10 rotl		3·54	3·16	36·2	62·6
809	4th	Apr. 4th, '07	0·10 rotl		3·34	2·90	30·7	61·7
873	5th	Apr. 13th, '07	0·10 rotl		2·94	2·87	32·5	62·0
874	6th	Apr. 24th, '07	0·05 rotl		2·55	2·76	25·5	60·4
875	7th	May 5th, '07	0·035 rotl		2·55	2·89	26·2	60·6
876	8th	May 16th, '07	0·013 rotl		2·15	2·56	20·2	58·7

Tapped by making a number of cuts or gashes. No inoculation

814	1st	Mar. 7th, '07	0·060 rotl	No marked difference from the gum exuding by the ordinary methods of tapping, except that, the amount of gum being less, the tears were smaller	2·35	2·94	31·7	61·8
815	2nd	Mar. 16th, '07	0·04 rotl		2·78	2·55	27·7	60·8
816	3rd	Mar. 26th, '07	0·05 rotl		2·55	2·86	29·0	61·3
817	4th	Apr. 4th, '07	0·04 rotl		2·15	2·74	26·7	60·6
877	5th	Apr. 13th, '07	0·04 rotl		1·95	2·69	21·2	59·2
878	6th	Apr. 24th, '07	0·02 rotl		2·35	3·27	22·2	59·4
879	7th	May 5th, '07	0·02 rotl		2·55	2·75	21·0	59·1
880	8th	May 16th, '07	0·013 rotl		2·74	2·73	23·5	59·6

Tapped by a series of small cuts fairly close together. Attempted inoculation. (*See page* 422)

810	1st	Mar. 7th, '07	0·028 rotl	All the gum was in small pieces, becoming more glassy towards the end of the season. The colour was slightly lighter than that of gum from trees tapped in the ordinary manner	2·94	3·42	35·5	62·0
811	2nd	Mar. 16th, '07	0·02 rotl		2·74	3·05	29·7	61·5
812	3rd	Mar. 26th, '07	0·03 rotl		3·14	3·20	39·2	63·0
813	4th	Apr. 4th, '07	0·02 rotl		2·74	3·08	28·0	61·1
881	5th	Apr. 13th, '07	0·02 rotl		2·55	2·97	24·7	60·3
882	6th	Apr. 24th, '07	0·016 rotl		1·77	2·60	21·0	59·0
883	7th	May 5th, '07	0·003 rotl		1·95	2·61	22·5	59·5
884	8th	May 16th, '07	0·001 rotl		1·95	2·63	23·0	59·7

W. Beam

Fig. 212.—Loading Gum on Camels for Transport to the River

Of the gardens selected for experiments, that of Ali Nur-ed-Din furnished the most complete series of results, since it was possible in it to secure sufficient of each group—small, medium and large—for the purpose.

The following tables give the averages of results from the three classes of trees, and what may be taken roughly as a general average of the garden as a whole :—

		Large trees	Medium trees	Small trees
Average yield of gum per tree ...		1·90	1·33	0·75
Average acidity (milligrams potassium hydroxide) ...		2·45	2·74	2·61
Average ash		2·96	2·90	2·96
Average viscosity of 20 per cent. solution	Degrees of retardation in torsion viscosimeter	34·7°	30·2°	27·9°
	Grammes of sugar, per 100 c.c. of solution, required to produce the same viscosity	62·3	61·5	61·0

AVERAGE OF ALL TREES IN GARDEN OF ALI NUR-ED-DIN

Yield		1·33
Acidity		2·60
Ash		2·94
Viscosity of 20 per cent. solution	Degrees of retardation	30·9
	Sugar equivalent	61·6

From the above results it will be seen that the proportion of harder glass-like gum varied considerably as the season advanced, and increased markedly towards the end. It is to be noted, however, that the harder gum was not the hard, strong gum, of high "viscosity strength," which was formerly found in Sudan mixed gum, and picked from it under the name of "Khartoum gum"; but that the solution yielded by it was even weaker in viscosity than that of the softer gum. It is also evident that Sudan (and, as will be seen below, Senegal) gums exhibit in their solutions two kinds of viscosity, one of them being false or abnormal. The latter is the form exhibited by certain samples which appear to dissolve completely in weaker solutions (5 to 10 per cent.), but in higher concentration yielding, especially on standing, a glairy mucus-like liquid, from which there separates a greater or less amount of true solution of lower viscosity. This behaviour appears to characterise the gum of early collections, more especially the harder tears, since when these were separated from the softer, and tested, the condition of comparative insolubility was found to persist in some cases up to the third collection, whereas the mixed gum is completely soluble, at least to all appearance, in 20 per cent. solution.

Normal and abnormal viscosity

The above facts point to the necessity of testing the solubility and viscosity of a gum in solutions of not less than 20 per cent.

Alteration on storage

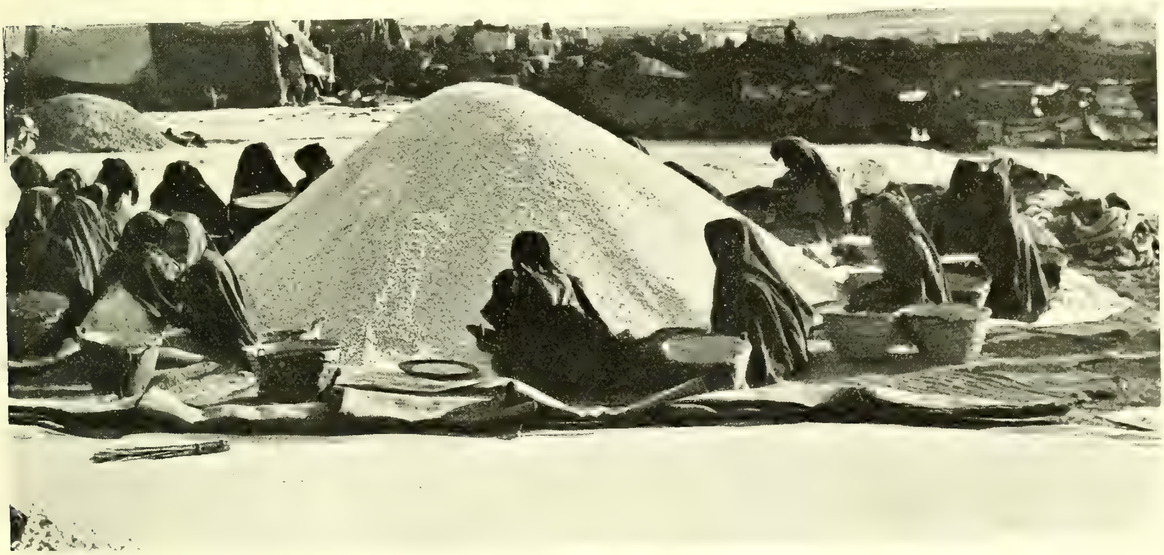
It was found that if the abnormal gums just mentioned are kept for a certain time they become perfectly soluble in solutions even of the highest concentration. In some cases (*e.g.* that of a sample of Senegal gum) the alteration was found to have taken place at the end of about two months, but more usually they require to be kept for three or four months. One sample required nearly two years, but this was exceptional.

The alteration, on storage, in the behaviour of the gum appears to be due to molecular re-arrangement. This view is borne out by the results of Mr. Edie's researches (*q.v.*).

The following results would appear to indicate that the behaviour just mentioned is a characteristic rather of the gum exuding as the result of tapping than of the

W. Beam

Fig. 213.—Loading Gum on Barge



W. Beam

Fig. 214.—Gum Picking. Omdurman

W. Beam

Fig. 215.—Bleaching Gum. Omdurman

gum from natural cracks or fissures in the bark (natural or wady gum), but the evidence is too limited to be anything more than suggestive.

	Young Trees		Old Trees		Young Trees in Valley Geneina	
	From tapped trees	"Natural" exudation	From tapped trees	"Natural" exudation	From tapped trees	"Natural" exudation
Viscosity of 20 per cent. solution — Determined, March, '07	83·5°	40·5°	77·5°	31°	122·5° (slightly ropy)	ropy solution
Viscosity of 20 per cent. solution — " Nov. '07	33·0°	40·0°	40·5°	29·5°	55° (no trace of ropiness)	35·3° (no trace of ropiness)
Acidity (milligrams KHO required to neutralise one gramme)	2·90	2·90	2·80	2·85	235	270
Ash	3·85	3·00	3·05	3·15	3·05	3·25

The colour of the gum of tapped trees is almost invariably lighter than that of "natural" exudations.

Up to the present the observations which have been made indicate that great reduction in viscosity, as the result of storage, takes place only in the case of the gum from early collections, and that a *soft* gum which yields a solution of high viscosity will alter materially and quickly on keeping.

Summary of results

The results of the examination of the gums from the several geneinas in the vicinity of Taiara, which have been tabulated on *pages* 424–428, may be summarised as follows :—

1. Gum of the earliest exudations, after tapping, is usually less soluble. This is especially the case with gum from old trees.

2. Storage results in a change by which the above gum becomes quite soluble.

3. Towards the end of the collecting season, the gum is found to become more hard and glassy, but in the case of the samples tested this year the hard gum did not yield a solution of high viscosity, as is usually the case with hard Kordofan gum.

4. There was a fairly regular decrease in "viscosity-strength" of the gum as the season advanced.

5. Contrary to the statements made by the gum collectors, and which appeared to be supported by the results of examination of several samples, the gum from older trees usually exhibits a slightly higher strength than that from younger trees. At the same time no hard, strong gum was found in any of the above collections.

The explanation of the absence of the stronger gum from these samples may be :—

(*a*) That by reason of the local conditions as to soil, height of water-table, etc., none of this variety is ever exuded near Taiara.

(*b*) That it is exuded only when tapping is performed immediately after the rains have ceased. It was intended that this should be done in October, 1907, but, through a misunderstanding, the instructions were not carried out.

(*c*) That it is exuded only in certain years under appropriate conditions of temperature and rainfall.

Gum dealers state that hard, strong gum comes to them in far larger quantity during the months of November and December, and a sample obtained from one of them, known to have been collected towards the end of 1907, was found to consist largely of this variety of gum.

This question will be studied in the collections which it has been arranged to have made during the coming season.

Commercial Grades of Sudan Gum

The following are some commercial grades of Sudan gum obtained from a local firm. The grading of gum in the Sudan and Egypt is based primarily upon the size of the tears or fragments, the terms used to designate the different sizes being "bold," "large," "medium," "granular," etc. Grading is, however, also based upon the quality. "Hard gum" (called in Trieste "Khartoum gum") is a special grade containing the hard glassy tears which exhibit solutions of high viscosity. Since the harder tears do not crush readily in transit, and are also usually stronger as regards viscosity of solution, it follows that as a rule the grades described as "bold" or "large" consist of stronger gum. This is not the case with bold or large bleached gum, since the variety selected for bleaching in the sun is always weaker as regards the viscosity of its solution. In a recent article on the "Uses, Properties, and Production of Gum," in the *Bulletin of the Imperial Institute* (Vol. VI., No. 1), it was stated that the comparative weakness of this grade of gum was due to its exposure to the sun. This is an error, the actual cause being as stated above. It may be pointed out that in many cases the bleaching of these gums is more apparent than real. Exposure to the sun results in the drying of the gum to such an extent that it becomes covered with minute cracks and fissures, which make it appear much lighter in colour than is actually the case. The effect might be likened to the apparent whitening of a piece of yellow glass by grinding the surface with emery.

The grading of gums

Bleaching

Effect of exposure to sun

Where the gum selected for the purpose is already of light colour, the bleaching in this way may be made to furnish a gum which dissolves to a practically colourless solution, without appreciably injuring its quality in any way except as regards friability. The actual advantage of such bleaching is questionable, but as long as the market demands a product of this kind it will of course continue to be furnished. It would seem preferable rather to select from the gum the tears which are naturally lighter coloured. While such selected gum would not have so fine an appearance, it would furnish a solution quite as light coloured as ordinary bleached gum, at much less cost for labour, and less attendant powdering of the gum, during bleaching and in transit, by reason of the excessive drying.

Bleaching of strong gum (the hard, glassy form) is not attempted. As already noted, the actual reduction in colour due to exposure to the sun is slight, and the deceptive appearance of bleaching due to the formation of minute cracks and fissures does not take place with this variety.

Kordofan gum is sometimes designated in the trade as "Turkey" gum.

"Turkey" gum

The term "sorts" is used to indicate an ungraded, natural gum. "All sorts" is rather what is meant.

"Sorts"

The following figures (*page* 434) are not to be relied upon as characteristic of the grades in question. "Medium sifted and cleaned sorts," for instance, has a higher viscosity of solution, not because medium-sized pieces are stronger, but because the given lot of gum from which it was selected happened to be of a higher viscosity.

Generally speaking, all that may be said as regards commercial grades of gum is that the so-called hard gum has a solution of higher viscosity and the grades selected for bleaching a lower one. The amount of foreign matter is of course materially less in the cleaned and selected samples.

The lower acidity of granular gum and "siftings" is probably due to neutralisation by alkaline matter in the associated sand, etc., when the sample is brought into solution.

Commercial grades of Sudan gum. Kordofan and Gedaref *Hashab* gums and Talh gum

COMMERCIAL GRADES OF SUDAN GUM

Description	Moisture per cent.	Bark, sand, etc., insoluble in water, per cent.	Acidity (mgms. of potassium hydroxide required to neutralise one gramme)	Viscosity of 20 per cent. solution: Degrees of retardation in torsion viscosimeter	Viscosity of 20 per cent. solution: Grammes of sugar, per 100 c.c. of solution, required to produce the same viscosity	Colour of 10 per cent. solution
Kordofan Gum. *Hashab*						
Gross gum as it is gathered. "Natural Turkey sorts"	9·03	0·34	3·14	32·0	61·85	Pale straw
Sifted and cleaned sorts	8·44	0·44	2·95	35·0	62.4	Pale straw
Sifted and cleaned sorts. Medium	8·50	0·42	3·14	47·7	64·6	Pale straw
Partly cleaned and sifted sorts	8·49	0·64	3·34	34·2	62·2	Pale straw
Bleached gum. Selected Bold	7·57	0·06	3·14	32·0	61·85	Pale straw
Bleached gum. Selected Medium	8·30	0·23	3·14	32·7	62·0	Pale straw
Half-bleached gum	8·05	0·17	2·95	35·0	62·4	Pale straw
Selected sorts. Bold	7·57	0·21	3·14	63·0	66·6	Pale straw
Selected sorts. Large	8·51	0·20	3·14	73·5	67·3	Slightly brownish tint
Hard selected sorts	8·93	0·16	3·34	63·0	66·6	Very pale straw
Granular sorts cleaned...	8·70	2·67	2·95	31·2	61·7	Yellowish
Pickings, partly cleaned	8·38	2·40	2·55	36·5	62·7	Dark straw
Pickings, uncleaned	8·38	3·10	2·35	37·7	62·8	Reddish brown
Siftings	7·45	20·12	1·95	22·2	59·4	Dark straw
Gedaref Gum. *Hashab*						
Sifted and cleaned sorts	8·52	1·12	2·95	24·0	60·0	Brownish
Talh Gum						
Sorts	7·77	2·87	4·50	34·0	62·2	Dark brown

Talh Gum

Talh gum is collected from two varieties of *Acacia seyal*, one known locally as "*talha hamra*," or red talh, and the other (*A. seyal*, var. *fistula*) as *talha beida*, or white talh. These trees are not tapped by the gum collectors, who simply pick off such gum as exudes from accidental cracks or fissures in the bark. The crude gum of both varieties has apparently identical qualities. It is inferior to hashab gum, but finds a ready sale at a lower price. Talh gum from *Acacia seyal*

Talh gum as found in the market is in small pieces or fine powder, the gum being exceeding friable and the tears falling to powder during transport. It consists of a mixture of various coloured particles, ranging from absolutely colourless through shades of yellow and brown up to dark red. It is frequently more acid than the gum from *A. verek*, and sometimes possesses a distinctly sour taste. Its solution is usually fairly dark, becoming much more so on exposure to the air. Form of Talh gum

Twelve samples of talh gum from Kassala district were examined with the following results:— Analysis of Talh gum

		Minimum	Maximum	Average
Acidity (equiv. to milligrams KHO)		2·75	6·29	3·76
Ash, per cent.		2·42	4·42	2·97
Viscosity of 20 per cent. solution	Degrees of retardation	29·2	43·0	36·3
	Sugar equivalent, grammes per 100 c.c. of solution	61·3	63·8	62·6

All yielded coloured solutions which became much darker on exposure to the air and had a more or less pronounced sour taste.

By selecting only the colourless pieces a very marked improvement was noted. Thus— Analysis of selected Talh gum

		Minimum	Maximum	Average
Acidity (equivalent to milligrams KHO)		2·80	3·55	3·13
Ash, per cent.		2·67	2·89	2·81
Viscosity of 20 per cent. solution	Degrees of retardation	29·2	34·1	31·6
	Sugar equivalent (grammes per 100 c.c. of solution)	61·3	62·3	61·6

The solutions were in all cases free from sour or other marked taste and practically colourless, with little or no tendency to darken on exposure to air.

An experimental tapping of red talh trees was carried out at our request by S. A. Wood, Inspector in the Woods and Forests Department. The result was a greatly increased yield and a very decided improvement in quality, especially as regards the colour of the gum, its taste, acidity, and the absence of darkening of the solution on exposure to the air. Experiments are about to be undertaken in order to determine the best method of tapping, since under some conditions the gum exudes in such large masses that, apparently, fermentation, attended by coloration and increased acidity, is the result.

The following are the results of examination of a sample of good gum obtained by tapping and a comparison with the ordinary gum collected in the same district (Sennar) from untapped trees.

	"Natural exudation"	From tapped trees
Laboratory number	944	943
Moisture, per cent.	10·6	9·30
Acidity (equivalent to milligrams KHO)	3·37	2·89
Ash, per cent.	3·35	3·16
Viscosity of 20 per cent. solution — Degrees of retardation	44	39
Viscosity of 20 per cent. solution — Sugar equivalent, grammes per 100 c.c. of solution	64	63·1
Taste	Bitter	No marked taste
Colour and behaviour of 20 per cent. solution	Very dark, becoming darker on standing, and depositing a dark coloured ppt.	Amber. Darkens only very slightly on exposure.

GUM OF ACACIA ARABICA

Gum of *Acacia arabica*

The *Acacia arabica* (*A. vera*, Willd), known in the Sudan as "sunt," was the original source of true gum arabic. It exists in fair amount, but is employed rather as a timber and as firewood. The native method of tapping the tree differs from that employed in the case of *A. verek*. It consists in chopping out a section, say two or three inches in diameter, of the bark and bruising the tree by a number of rather heavy blows around the cut. Except that it is, on the whole, rather darker than hashab gum, sunt gum is usually of very good quality. The following may be taken as an average sample :—

Laboratory Number	425
Source	Sennar
Moisture, per cent....	11·65
Ash, per cent.	2·02
Acidity (milligrams KHO required for 1 gramme)	2·09
Viscosity of 20 per cent. solution — Degrees of retardation	40·70
Viscosity of 20 per cent. solution — Sugar equivalent (grammes per 100 c.c. of solution)	6·33

The gum was completely soluble and its solution of light yellow colour and practically tasteless.

Some results of examination of gums from less known sources, kindly supplied us, in most cases, by the Director of Woods and Forests, are given below. These results should be regarded as suggestive only, since a reliable judgment as to the character of the gum which a tree is capable of furnishing can probably only be formed by a consideration of results of examinations extending over an entire gum-producing season. Single samples may give results altogether misleading.

ACACIA VERUGEA, Schwft. *Arab.*—Kuk.

Kuk gum from *Acacia verugea*

A sample of this gum was found to be mainly dark in colour and in more irregular masses than the tears of ordinary hashab gum.

On treatment with water the gum does not form a true solution, except in part. A glairy, somewhat gelatinous mass separates, as sometimes occurs in the early collections of ordinary gum.

The ash was 2·29 per cent. and the acidity was equivalent to 1·77 milligrams of potassium hydroxide per gramme of the gum.

The viscosity of the 20 per cent. solution could not be correctly measured for the reason stated above.

Some small pieces of light-coloured gum picked from this sample were found to be quite soluble at first, but on standing the solution became of a granular consistence.

ACACIA SUMA, Kurz. *A. campylacantha*, Hochst.

Gum from *Acacia suma*, Kurz.

This tree is known locally as Kakamut, or Sinein. A sample of gum from it was found to be completely soluble, but the solution had a mawkish disagreeable taste with a flavour of turpentine. All the gum was of dark colour :—

Moisture ..	...	12·32 per cent.
Acidity (milligrams KHO per gramme)	...	3·79
Ash	..	2·25 per cent.
Viscosity of 20 per cent. solution	Degrees of retardation ...	20
	Sugar equivalent (grammes per 100 c.c. of solution) ...	58·5

ODINA FRUCTICOSA, Hochst. *Arab*, Leyun

Gum from *Odina fructicosa*

This gum was found to be completely soluble. The solution was yellow and the taste fairly good, but the viscosity of the solution was rather low. The results were as follows :—

Moisture	...	12·01 per cent.
Ash	...	2·40 ,, ,,
Acidity (equivalent to milligrams KHO)	...	1·92
Viscosity of 20 per cent. solution	Degrees of retardation ...	27·5
	Sugar equivalent (grammes per 100 c.c. of solution) ..	60·8

COMBRETUM, sp. *(Trifoliatum* or *Hartmannium)* *Arab*, Subakh

Subakh gum from *Combretum*, sp.

Several samples of this gum were examined. These varied greatly in appearance, the better ones being light amber in colour and in round and vermicular-shaped tears. An examination of such a sample gave the following results :—

Moisture	...	9·41 per cent.
Ash	...	2·02 ,,
Acidity (equiv. to milligrams KHO)	...	3·34
Viscosity of 20 per cent. solution	Degrees of retardation ...	149
	Sugar equivalent (grammes per 100 c.c. of solution)	69
Colour of solution	...	Light amber. Darkens on exposure and deposits a brown precipitate
Taste	...	Practically tasteless

Another sample of this gum, said to be from the same species of tree, was found to be in large irregular fragments, brownish black and almost opaque. It was not soluble in water, but a mixture of about 2 per cent. formed with water a jelly-like mass.

It does not seem likely that these two samples came from the same species of *Combretum*.

STERCULIA CINERIA and STERCULIA TOMENTOSA

Tartar gum from *Sterculia cineria* and Da gum from *Sterculia tomentosa*

The former of these is known as Tartar (*Arab*), and the latter Da or Kandi (*Golo*). Both exude a gum apparently identical in character, and resembling gum tragacanth rather than ordinary gum-arabic. On adding to water they do not dissolve to form a clear solution, but swell up and form a stiff jelly.

The gum from *S. tomentosa*, obtained in Senegal, has in recent years come into use in the treatment of fabrics.

The following are some results of examination of this gum, compared with a sample from Senegal.

Laboratory No.	548	542	543
Gum of	*S. tomentosa*	*S. cineria*	*S. tomentosa*
Source	Bahr-el-Ghazal	Sennar	Senegal
Moisture	15·26 per cent.	13·12 per cent.	8·99 per cent.
Ash	7·05 „ „	5·48 „ „	6·70 „ „
Acidity (equiv. to milligrams KHO)	13·79	14·59	13·00

Two per cent. of these gums forms with water a colourless, slightly granular jelly.

Another sample, from the frontier of Persia and India, behaved in a similar manner.

Determination of Viscosity of Gum Solutions

Determination of viscosity of gum solutions

In the Second Report of these Laboratories attention was called to the application of the torsion viscosimeter to the testing of gum solutions and the methods of using the instrument were explained in detail. An experience of two more years, during which a very great number of tests were made, confirms the favourable opinion which was formed at that time. The great advantage which it offers over glass forms of viscosimeters (in which the time of outflow through a capillary tube or orifice is noted) is that the single instrument may be employed to determine with accuracy the viscosity at all concentrations, from the lowest up to the highest that it is possible to make. If glass flow instruments are employed and it is desired to make determinations at say 10, 20, and 30 per cent. concentrations, it will be necessary to have an instrument adjusted to each of these. A 20 per cent. solution

Torsion viscosimeter

Glass viscosimeters

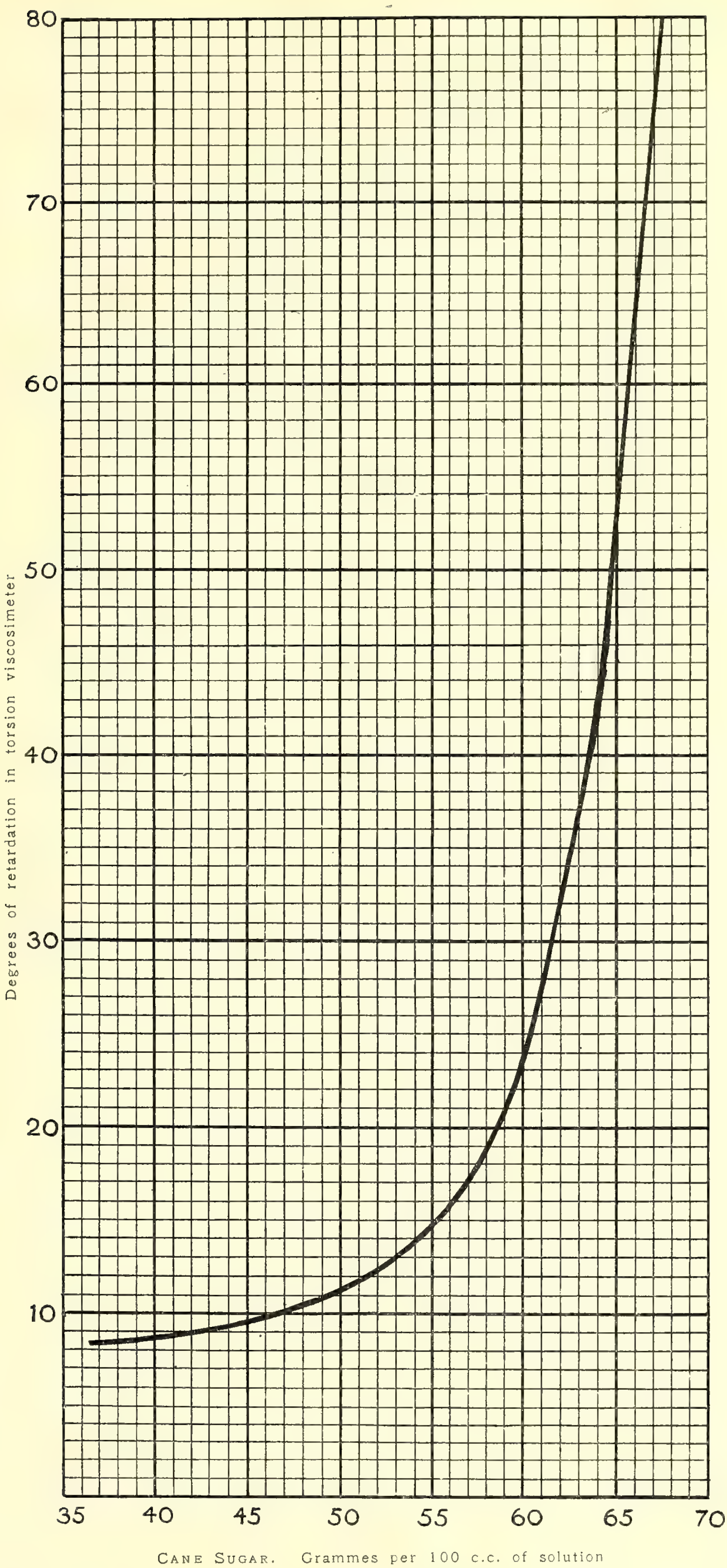


Fig. 216.—Viscosities of Cane Sugar Solutions

will not flow through a capillary tube such as must be employed if the determination of viscosity of a 10 per cent. solution is made with anything even approximating accuracy.

In our own experience the determinations of the viscosity of gum in 10 per cent. solutions has often furnished results markedly at variance with the results obtained in higher concentration. This is apparently especially the case with comparatively fresh gum, that is, from one to three months after collection. It is probably connected with the presence of the variety which, in higher concentration, shows itself by forming a glairy, oily liquid, not a true solution, the determination of the viscosity of which has probably little practical value, and the figures of which are certainly not comparable with those yielded by normal gum solutions.

Strength of solutions employed

If determinations of viscosity are made in 10 per cent. concentration, a solution of 20 or 30 per cent. should also be made up and allowed to stand for from 24 to 48 hours in order to determine whether there is any alteration in the solubility of the gum at the end of that time.

From enquiries made of gum handlers in Trieste, Bordeaux and America, it was found that the results of viscosity determinations made on 20 to 30 per cent. solutions were considered much more satisfactory, being more in accordance with the behaviour of the gum in actual use.

Ostwald's viscosimeter, a simple form for rough determinations

The cost of the torsion viscosimeter is considerable and its setting up and adjustment necessitates a certain amount of skill in the operator. It is desirable, therefore, that some simple form of instrument be devised for general use among gum dealers and manufacturers. Any one of the forms of flow apparatus will answer for such rough determinations provided it is adjusted to the concentration of solution to which it is applied. The best of these, and a form capable of furnishing very accurate results, is that recommended by Ostwald, and shown in Fig. 217. The determination is made by introducing a definite fixed quantity of the solution at C, and drawing it up by suction until it stands at the mark A. The time required for the liquid to flow from A to the lower mark B is noted. The apparatus should stand in a tall beaker containing water at the standard temperature.

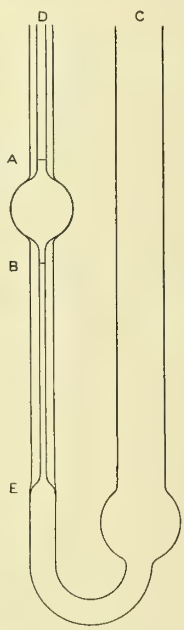


Fig. 217
Ostwald's viscosimeter

The upper small bulb may conveniently have a capacity of 5 c.c., and the tube of fine bore a length of 10 centimetres. 10 c.c. of the liquid to be tested should be introduced at C.

The tube should be of such a bore that the time of flow should be between 50 and 100 seconds.

Terms in which viscosity is best recorded

Whatever the form of instrument adopted, it is desirable to record the viscosity in terms of the number of grammes of pure dry cane sugar per 100 c.c. of solution (made at 60° F.) which is required to produce the same viscosity at the temperature selected. All the viscosities mentioned in this article were determined at 90° F., which was chosen as being about the average temperature of a room in Khartoum.

As will be seen from the curve of viscosities of cane sugar solutions which is charted on page 439, the expression of viscosities of gum solutions in terms of gramme-sugar degrees is much more satisfactory with ten per cent. solutions than with those of twenty per cent. or more, as the curve beyond 20° retardation (which is not likely to be exceeded by even the strongest gum in ten per cent. solution) is very steep.

Notes on the Chemistry of Sudan Gums

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On my arrival in Khartoum, I found that the principal problem in connection with the chemistry of Sudan "Gum Arabic" was to discover the cause of the marked differences noticed by Dr. Beam in certain physical properties of the gum, such as hardness and viscosity. These differences are discussed fully in Dr. Beam's report. A second point of interest was to discover some specific properties of each kind of gum, so that it would be possible, for example, easily to distinguish "Hashab" from "Talh," "Sunt," or any of the other gums occurring in the Sudan. This cannot be always done by physical tests, such as viscosity. The literature on gums is comparatively scanty, and few observers mention more than the acidity, total ash, and optical activity of the gum. O. Fromm[1] goes into the question of the valuation of gum-arabic, giving special attention to the colour, viscosity, optical activity, and volume of insoluble matter. He found that some of the properties, such as viscosity of solution and acidity, decreased on keeping the gum for some time. Unfortunately, no mention appears to be made of the actual source of his samples, which are described chiefly by the commercial names, such as "Kordofan" or "Senegal" gum.

Dr. Beam has mentioned that at the time when Fromm conducted his experiments there would be very little Hashab gum from Kordofan in the market, and some of the latter's figures, for example, of optical activity, vary widely from those obtained by me with gums of known origin. These differences will be referred to later.

Pentoses in gums

R. Hefelmann[2] determined the amount of pentoses in 25 samples of commercial gum-arabic, but not all from the same species of tree. He found no relation between the amount of pentoses and the trade value of the gum, and he also remarks on the fact that the viscosity is the best guide to the value of any particular sample. A few other observers have given figures with regard to isolated specimens of particular gums, mentioning acidity and optical activity, but there appears to have been little or no attempt to study the gum of any particular species of tree under varying conditions, such as soil, age of trees, or season of collection of the gum. Since, from the commercial point of view, the viscosity is the most important character of a gum, it is of great interest to investigate the changes of viscosity, noting carefully differences in conditions as mentioned above, and to attempt to correlate these differences with variations in other physical and chemical properties of the gum.

Changes in viscosity

Dr. Beam has investigated the effect of the age of the trees, and the season of collection, in causing variations in viscosity and acidity in Hashab gum from the Sudan as completely as the samples obtainable would allow.

From a chemical point of view, it seems at first sight probable that these variations in viscosity would be accompanied by corresponding variations in the various constituents of the gum molecule. The simplest way to test this seemed to be to estimate the proportions of pentoses and hexoses produced on hydrolysis of the gum by dilute acid. In gum-arabic arabinose is the pentose produced, and galactose the principal or only hexose.

[1] *Zeits. f. Anal. Chemie*, 1901, XL., p. 143.

[2] *Zeits. f. öffentl. Chemie*, VII., p. 195.

Sugar in gums

It may be mentioned that all the gums examined contained a small quantity of reducing sugar, varying in Hashab gum from a mere trace up to about 0·15 per cent. This does not form an essential part of the gum, and may be readily removed by dialysis. The sugar is most probably derived from the sap of the tree, some of which would adhere to the gum on drying. The nitrogenous matter in the gums examined is also very small in quantity, and quite independent of the strength of the gum. It also is probably derived from the sap.

Hashab gum

Examination of Hashab Gum

The pentoses were estimated in one gramme of gum by distilling with 12 per cent. hydrochloric acid, and precipitating the furfurol produced with phloroglucin. The method followed was that described by Kröber and Rimbach.[1] From the precipitate the pentoses were calculated as arabinose. I found that this method was more convenient, and gave more concordant results with the same sample of gum, than the method of precipitating the furfurol with phenylhydrazine.

I at first attempted to estimate the galactan portion of the gum molecule by oxidising the gum with dilute nitric acid, filtering and weighing the mucic acid.[2] It was very difficult, however, to get two determinations of galactan in the same sample of gum to give results sufficiently nearly equal, though I found this method very useful in giving an approximate idea of the relative proportions of pentoses and hexoses produced on hydrolysis.

The total amount of reducing sugars was estimated by boiling a four per cent. solution of gum in five per cent. sulphuric acid for five hours under a reflux condenser. The reduction was then determined in five cubic centimetres after neutralisation, by boiling with a slight excess of Fehling's solution. The cuprous oxide was filtered off, washed and ignited. It was found that hydrolysis was complete in nearly every case after four hours' boiling.

The most important results obtained by this method of examination are shown below :—

Source of Gum	Phloroglucide from 1 gramme gum	Per cent. of arabinose	Grammes CuO from 1 gramme gum after hydrolysis	Per cent. of hexoses
30 trees, 1st collection	0·3184 grms.	35·37	2·005	52·22
„ 2nd „	0·3191 „	35·45	2·025	53·04
„ 3rd „	0·3193 „	35·48	2·024	52·94
„ 4th „	0·3153 „	35·02	2·004	52·54
„ 5th „	0·3175 „	35·27	1·973	50·88
„ 6th „	0·3176 „	35·29	1·966	50·52
Kordofan, December, 1907	0·3148 „	34·97	1·980	51·54
Senegal, *grosse blanche*	0·3113 „	34·59	1·975	51·72
Senegal, *bas du fleuve*, 1908	0·3030 „	33·66	1·985	53·17
Kordofan hard glassy gum	0·3094 „	34·37	1·955	51·04
Kordofan "bleached" gum	0·3020 „	33·52	1·965	52·35
Kordofan ropy gum	0·3195 „	35·49	1·985	51·18

[1] *Zeits. f. angew. Chemie*, 1902, XV., p. 477.
[2] Allan, "Commercial Organic Analysis," 3rd Ed., Vol. I., p. 546.

The gum in the first six instances above was from thirty middle-sized trees in Sheikh Ali Nur-ed-Din's garden, of which a more detailed account is given by Dr. Beam. The exact source or description of the trees in the case of the other gums is not known, except that they are from Kordofan and Senegal. The hard, glassy gum from Kordofan was a picked sample with a high viscosity. One of the samples was a so-called "bleached" gum after exposure to the sun. This, as Dr. Beam has pointed out, is not a true bleaching, the white effect being due to the presence of a large number of cracks and small fissures in the gum. This gum is very friable.

The last specimen of gum mentioned yielded a ropy solution when it was first examined in the laboratory, but now a true solution is obtained which develops no ropiness on standing over-night.

Calculation of the glucoses

It may make the tables clearer if the method of calculating the glucoses is illustrated by an example. In the first case the actual weight of phloroglucide obtained on adding phloroglucin to the furfurol resulting from the distillation of one gramme of gum with hydrochloric acid was 0·3184 grammes. From tables given in Kröber's paper this is found to correspond to 0·3537 grammes of arabinose, which will reduce a quantity of Fehling's solution equivalent to 0·856 grammes of cupric oxide. The total reduction by one gramme of gum after hydrolysis was 2·005 grammes cupric oxide, so that there is a reduction of 1·149 grammes CuO due to glucoses or galactose. The amount of glucoses required for this reduction is 0·5222 grammes, or 52·22 per cent. of the gum.

These results, especially in the series of six samples of gum from the same set of trees, are at first sight surprising, as they show that, in spite of the different season of collection and differences in the proportions of friable and hard glassy gum, the products of hydrolysis may be said to be the same throughout. The differences in reduction of cupric oxide are multiplied five-fold in the table, as the solution taken only contained 0·2 grammes of gum. No allowance, either, is made for differences in moisture, ash, adherent bark, etc.

Pentoses and hexoses

The other six samples show that the proportions of pentoses and hexoses remain practically the same in spite of locality or age of the gum. It would have been interesting to examine the gum of *Acacia verek*, from other sources than the Sudan or Senegal, but there were no specimens in the laboratory. Some gums collected two years ago gave the same figures as specimens collected in the early months of 1908. Several other samples of gum were examined in the same manner, and gave results within the limits mentioned in the table.

Optical activity of gums

An important feature in the recognition of gums is their optical activity. Fromm[1] states that the rotation due to a 10 per cent. solution of air-dried "Kordofan" or "Senegal" gum varies from about $-1°$ to $+3° 21'$ in a tube 100 mm. in length, with variations in abnormal cases ranging from almost $-5°$ to over $+9°$. He mentions that the best varieties without exception give a negative reading, but I have found that all samples of Hashab gum examined gave a negative reading, and within much narrower limits than Fromm gives. Greig Smith, in his work on the bacterial origin of gums, mentions that according to various authors the natural gums vary constantly in their optical activity, but I have only found this to be so in the case of gums from different species of trees.

I have also estimated the optical activity of a solution of gum after hydrolysis. The gum was hydrolysed as described for the estimation of total reducing sugars, and the rotation in a 100 mm. tube observed. From this the rotation of a 10 per cent. solution of gum after hydrolysis was calculated.

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[1] *Zeits. f. Anal. Chemie*, 1901, XL., p. 143.

The following table shows the principal results, the temperature at the time of observation being 34° C. :—

Source of Gum	Rotation of a 10% solution in a 100 mm. tube	Rotation of a 10% solution in a 100 mm. tube after hydrolysis
30 middle-sized trees, 1st collection	− 3·01°	+ 5·48°
,, ,, 2nd ,, ...	− 3·00	+ 5·45
,, ,, 3rd ,, ...	− 2·95	+ 5·45
,, ,, 4th ,, ...	− 2·89	+ 5·40
,, ,, 5th ,, ...	− 2·81	+ 5·48
,, ,, 6th ,, ...	− 2·89	+ 5·48
30 small trees, 1st collection, hard portion	− 3·13	+ 5·42
,, ,, 2nd ,, hard ,, ...	− 3·14	+ 5·48
,, ,, 2nd ,, soft ,, ...	− 2·93	+ 5·42
,, ,, 3rd ,, hard ,, ...	− 3·03	+ 5·49
,, ,, 3rd ,, soft ,, ...	− 2·95	+ 5·43
,, ,, 4th ,, soft ,, ...	− 2·85	+ 5·50
,, ,, 5th ,, soft ,, ...	− 2·98	+ 5·47
,, ,, 6th ,, soft ,, ...	− 3·07	+ 5·56
30 large trees, 2nd collection, hard portion	− 2·94	+ 5·38
,, ,, 2nd ,, soft ,, ...	− 3·02	+ 5·55
,, ,, 5th ,, hard ,, ...	− 2·77	+ 5·35
,, ,, 5th ,, soft ,, ...	− 2·89	+ 5·50
Kordofan gum, hard and strong	− 3·00	+ 5·30
,, ,, "bleached" sample	− 2·88	+ 5·38
,, ,, giving a ropy solution	− 2·91	+ 5·40
,, ,, December, 1907	− 3·11	+ 5·35
Gedaref gum, January, 1908	− 3·09	+ 5·33
Senegal gum, *grosse blanche*	− 2·84	+ 5·48
,, ,, *petite blanche*	− 2·70	+ 5·48
,, ,, *bas du fleuve*, 1908	− 2·93	+ 5·42

The gum from the small, middle-sized and large trees in the above table came from Ali Nur-ed-Din's garden, and is the same as that described in greater detail by Dr. Beam. This table of optical activities is of great interest in that it indicates a constant specific rotation for Hashab gum, not only in aqueous solution, but also after hydrolysis with sulphuric acid. In a few of the collections the gum had been divided into two portions, one consisting of the soft friable gum, and the other being composed of the hard glassy tears. We thus have gum from trees of very different sizes, and, probably, these differed in age correspondingly. The season during which the gum from these trees was collected was from the middle of January until the exudation of gum stopped, none unfortunately being gathered in November or December.

Specific rotation for Hashab gum

It will be seen that the rotation of the Senegal gums is practically the same as the Kordofan samples, and some specimens which had been in the laboratory for two years also showed the same rotation. The gums mentioned differ slightly in moisture and ash, but the differences would only affect the rotation to a slight extent. I attempted to prepare a sample of the free gum-acid from some selected strong gum from Kordofán by acidifying and then dialysing, but found that a trace of calcium was still left, and after evaporating the gum-acid solution to dryness it did not very readily dissolve, probably owing to some change taking place in the drying process, which was completed at about 105° in an air oven. On hydrolysis of some of the acid, however, it was found to give a rotation of + 5·64°. There was still about 4·7 per cent. of moisture in this acid.

The rotation of the gum after hydrolysis throws considerable light on the question of the constancy of different samples of Hashab gum, as shown by the ordinary methods of investigation. All soluble arabin gums, to which references are made in the literature available, have been found to be hydrolysed by dilute sulphuric acid into arabinose and galactose. I confirmed this in the case of a few specimens of Hashab gum by examining the osazones produced on precipitation with phenylhydrazine acetate, but I did not examine any of the series systematically in this way, thinking it unnecessary to do so. The rotation of a 10 per cent. solution of these series of gums after hydrolysis, however, taken into consideration with the proportions of pentoses and hexoses, points, I think, clearly to the fact that the individual pentoses and hexoses are present all through—the specific rotations of the different sugars varying widely. Thus, at ordinary temperatures, the $[\alpha]_D$ of arabinose is about + 104·4°; of xylose, + 18·5°; of galactose, + 81·4°—these values varying slightly according to temperature and concentration.

Before discussing the differences in hardness and viscosity further, it may be of interest to give a few determinations of the inorganic constituents of Hashab gums. The ash is usually stated to consist of lime, potash and magnesia, but I do not remember seeing the proportions in which these occur recorded. The amount of total ash varies slightly in different samples, owing partly to the fact that more or less of the calcium carbonate is decomposed by the high temperature at which the gum was incinerated. In no case did I find any phosphates, sulphates or chlorides in the ash.

Inorganic constituents of *Hashab* gums

The figures given are grammes of the metals in 100 grammes of gum.

Kind of Gum	Magnesium	Potassium	Calcium
Kordofan strong glassy gum	0·257	0·710	0·773
Kordofan "bleached" gum	0·266	0·596	0·779
Kordofan gum, giving ropy solution	0·212	0·661	0·818
Ropy gum from different locality	0·198	0·730	0·785
Senegal gum, *grosse blanche*	0·185	0·763	0·706
From 30 middle-sized trees	0·246	0·638	0·687
,, ,, ,, ...	0·281	0·614	0·664
,, ,, ,, ...	0·292	0·669	0·558

The last three samples of gum were from the garden of Ali Nur-ed-Din, and represent the first three collections. The ash of all these gums contains a very small quantity of silica also. It will be seen that in spite of considerable differences in the source and character of the gums, the total quantity of each metal (and also their relative proportions) remains much the same throughout; and the differences may perhaps be accounted for by the presence of dirt or soil which became accidentally mixed with the gum during the time of collecting.

Determination of osmotic pressure

A purely physical method of examining gums which does not appear to have been employed hitherto is the determination of the osmotic pressure of a solution of the gum. The type of osmometer which I have employed for this is that described by Moore and Roaf.[1] It is specially adapted for the rapid diffusion of any crystalloids which may be in solution through the parchment-paper membrane. Moore and Roaf by this method have completely disproved the theory that colloids possess no osmotic pressure. Among other colloids employed was gum-arabic, a 6 per cent. solution of which gave an osmotic pressure of 134 mm. of mercury after five days; another sample gave a pressure of 142 mm. Gum tragacanth gave practically no osmotic pressure, but only a very dilute solution of this gum can be obtained.

In my experiments the final reading of the manometer was always made after bringing the temperature of the solution to the original temperature, thus avoiding any slight error due to expansion or contraction of the solution inside the osmometer. The instrument was not disconnected until the pressure had been stationary for at least forty-eight hours. In all cases a solution containing six grammes of dry gum in 100 c.c. was employed.

Gum	Osmotic pressure in mm. of mercury	Temperature
30 middle-sized trees, 1st collection	152	32·5° C.
,, ,, 2nd ,, ...	164	31·5
,, ,, 3rd ,, ...	164	32
,, ,, 4th ,, ...	167	32
,, ,, 5th ,, ...	170	32
,, ,, 6th ,, ...	165	32
Kordofan "bleached" gum	110	23
,, selected strong gum	127	23
Gum yielding ropy solution—A	140	21
,, ,, ,, B	141	22
,, ,, ,, C	118	19·5
Kordofan gum, hard tears, yielding a weak solution	102	27·5
,, ,, December, 1907	125	32·5
Senegal gum, *grosse blanche*	114	16·5

These results, while they may have been affected to a slight extent by the temperature, show that there is a very marked difference in the osmotic pressure of Hashab gum. On the whole the tendency seems to be for the more viscous gums to have a higher pressure than the weaker varieties. Unfortunately I was unable to test the osmotic pressure of any samples of gum within say a month of their being collected. Dr. Beam has shown

[1] *Bio-chemical Journal*, Vol. II., p. 34.

that in a considerable number of cases a gum which soon after being collected yields a viscous solution, on being kept for some months becomes much less viscous. These changes have also been noted by Fromm, who mentions that this decrease in viscosity is accompanied by an increase in the proportion of gelatinous insoluble matter. Dr. Beam's experience of Hashab gums, however, is the reverse in this latter respect—gums which at first yielded a ropy solution or a mixture of true solution and gelatinous matter invariably gave a true solution on being kept for several months. The gums marked A, B and C in the table are instances. In the Second Report of the Wellcome Research Laboratories, *page* 236, Dr. Beam calls attention to the fact that a solution of gum made at ordinary temperature has a much greater viscosity than a solution made with hot water. I am inclined to think that this change is due to the same cause as the gradual decrease in viscosity in a gum which has been kept for a considerable time. This change, and the wide range in osmotic pressures, it seems reasonable to attribute to some molecular change in the gum, which may be of the nature of polymerisation. I have been unable in the time at my disposal to examine these gums in the method described by O'Sullivan[1] in his exhaustive work on the products of decomposition of arabic acid, my object being rather to see what differences were obtained by the methods described with gums of varying strength. It may be that the nucleus acid to which the sugar residues are combined varies with the physical properties of the gum, or there may be varying proportions of the sugar residues split off from the different gums when hydrolytic action of varying intensity is employed. I think that my figures suggest that on complete hydrolysis with 5 per cent. sulphuric acid, however, the products obtained are the same, independent of the hardness or viscosity of the gum.

Molecular change in gums

In his paper on Geddah gum, O'Sullivan found that the number of sugar residues attached to the nucleus acid varied, and in some cases the gums contained mixtures of the same gum acids, but in different proportions. I am unaware, however, if these gums were obtained from the same species of tree, as gum-"arabic" from different species of acacia is widely different in chemical composition, as I shall show later.

Even if these Geddah gums were all from the same source, however, it is quite reasonable to suppose that in Hashab gum the changes in physical properties when the gum is merely kept at ordinary temperatures is due to some molecular change, as it is improbable that changes would occur in the actual proportions of the sugar residues or the gum acids.

If freshly-collected gum from various sources were available it would be very interesting to examine it chemically and physically at intervals of a few weeks, so as to discover if any such differences occur such as O'Sullivan found in the case of Geddah gum, and also if the osmotic pressure and viscosity varied together. Unfortunately none of the newly-collected gum of last season was available.

Talh Gum

Talh gum

I have examined a few samples of Talh gum from different sources—one the so-called "White Talh," the others Red Talh probably, though information as to the source was not always detailed. It is interesting to note that each sample has nearly the same composition and optical activity, so that probably molecular changes account for variations in hardness and viscosity, as suggested in the case of Hashab gums.

[1] *Journal of the Chemical Society* (Transactions), XLV., p. 41.

Gum	Percentage of arabinose	Percentage of hexoses	Rotation of a 10 per cent. solution in a 100 mm. tube	
			Before hydrolysis	After hydrolysis
Red Talh from barked trees	42·61	44·74	+ 5·05°	+ 8·05°
White Talh	—	—	+ 5·26	+ 8·12
Talh from Goz-El-Basabir	43·39	44·31	+ 5·26	+ 7·89
Talh	45·50	44·44	+ 5·16	+ 8·35

Rotation

A specimen of Red Talh gum, which had exuded naturally from the trees and which was examined, gave the same rotation as the specimen from barked trees.

These figures point to the possibility of readily distinguishing the presence of an appreciable quantity of Talh gum, which might have been used to adulterate Hashab gum.

Ash

The ash of two specimens of Talh gum was examined, and the figures are :—

Gum	Calcium	Magnesium	Potassium
Red Talh (barked)	1·0064	0·1914	0·1984
White Talh	1·0504	0·1784	0·1333

These figures represent grammes of metal in 100 grammes of gum. The proportion of potassium is much lower in these than in Hashab gums.

Osmotic pressure

A 6 per cent. solution of Red Talh gum from barked trees was found to give an osmotic pressure of 55 mm. of mercury. The gum exuding naturally gave a pressure of 48 mm.; and White Talh gum 41 mm. All these are very markedly different from any pressure developed by Hashab gums.

Sunt gum

Sunt Gum

A sample of Sunt gum was examined with the following results :—

Rotation

Percentage of pentoses		Percentage of hexoses		Rotation of a 10 per cent. solution in a 100 mm. tube Before hydrolysis		After hydrolysis
57·80	...	29·21	...	+ 7·73°	...	+ 8·25°

A single sample of Subakh, Kakamut, and Kuk gum respectively was examined in the same way. The results are :—

Gum	Percentage of pentoses	Percentage of hexoses	Rotation of a 10% solution in a 100 mm. tube	
			Before hydrolysis	After hydrolysis
Subakh (*Combretum*, sp.) ...	54·36	25·54	− 4·16°	+ 5·48°
Kakamut (*Acacia suma*) ...	34·74	—	− 1·16	+ 6·22
Kuk (*Acacia verugea*)	55·70	35·63	− 0·20	+ 7·07

The mineral matter in Kakamut and Subakh gum was found to consist of the following (grammes in 100 grammes of gum) :—

Ash

Gum	Calcium	Magnesium	Potassium	Sulphuric Acid (as SO_4)
Kakamut (*Acacia suma*) ...	0·3580	0·1924	0·7846	—
Subakh (*Combretum*, sp.) ...	0·6627	0·2458	0·2981	0·1563

The Subakh gum is the only one to contain any mineral matter except calcium, magnesium and potassium.

From the analogy of Hashab and Talh gum, there is every reason to expect that specimens of Sunt and other gums from different localities and collected at different seasons would show optical activity and proportions of arabinose to hexoses practically the same as those mentioned above, a polarimetrical examination being the most convenient. It should be stated that all the figures for rotation in this paper refer to the sodium flame.

The Bacterial Origin of Gum

Under the above title, Greig Smith[1] first published an account of researches conducted by him on the gum from *Acacia penninervis*, from twigs of which he isolated two kinds of bacteria. The prevalent type, which he calls *Bact. acaciæ*, produced, when grown on artificial media, a slime from which a gum of the arabin-galactan class was obtained by suitable treatment. This work has been described in great detail in subsequent papers by Greig Smith, who found that "gum-flux" in other species of trees could be accounted for by bacterial action also, and his results appear conclusive. Ruhland,[2] however, questions Greig Smith's view of the bacterial origin of gum, though he found that *Bacillus spongiosus*, isolated from diseased cherry trees, produced, when grown in artificial media, a slime from which a gum was isolated. This gum he found only to yield arabinose on hydrolysis, while the gum from cherry trees inoculated with the bacillus yielded a mixture of arabinose and galactose. In a later paper, Ruhland[3] discusses the formation of gum by the action of the oxygen of the air on a substance in the sap which might be called a reduced "gum-base." Gum bacilli

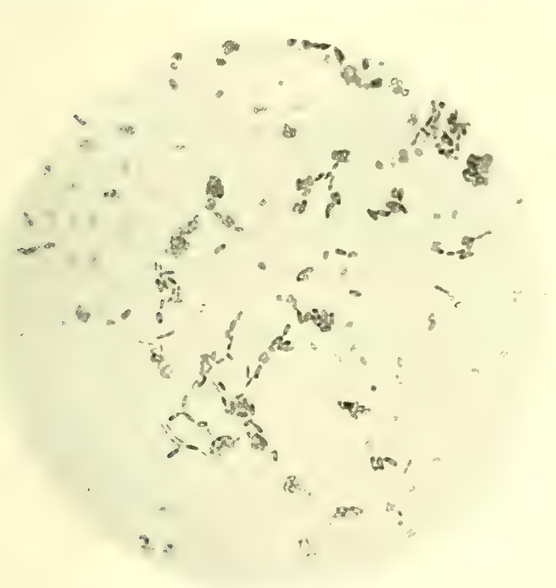

Fig. 218.—Bacterium isolated from stem bearing gum of *Acacia verek*, grown on saccharose potato agar. *Löffler's blue* × [illegible] *diam.*

Zimmermann,[4] working with *Acacia decurrens*, connects gum formation in this case with the borings of Ambrosia beetles, but he gives no account of what the method of gum formation is. He mentions one interesting point, however—namely, that all the artificial methods of gum production which have been described involve some injury to the tree. This, it will be readily seen, affords the bacteria more easy access to the tree, and they might simply be carried in mechanically. Gum and beetles

I have endeavoured to confirm Greig Smith's work in the case of Hashab gum; some branches, from which gum was exuding, being kindly sent from Kordofan by Mr. Tippetts, Junior Inspector at Taiara. After sterilising the exterior of small pieces of these branches

[1] *Proc. Linn. Soc. of N.S.W.*, 1902, Part III., September 24th.

[2] *Ber. deutsch. botan. Ges.*, 1906, XXIV., 393.

[3] *Ibid.*, 1907, XXV., 302.

[4] *Centralbl. f. Bakt. etc.*; II. Abt., Bd. XX., p. 716.

by passing them through the flame, I infected tubes of glucose gelatin with the fragments, and after 24 hours' growth plated out on saccharose potato agar. In every case practically a pure culture was obtained of the same organism. The colonies, after four days' growth at 35° C., had a puckered, dry appearance, and were rather greyish-yellow. The organism stained well with both Gram's and Löffler's stain. It was non-motile, and exhibited well-marked bipolar staining (Fig. 218). From the original plate cultures I sub-cultivated on the same medium, and then on the special medium containing lævulose and tannic acid recommended by Greig Smith for the production of slime. I found that the bacterium from Hashab did not grow at all well on this medium, but on a modified medium without tannin it grew well and produced a slime. Greig Smith mentions that this special medium for *B. acaciæ* is not suitable for all gum-producing bacteria. Having found a medium which promised fairly well for the production of slime, I proceeded on a larger scale, but unfortunately lost all the cultures, plates, etc., when the laboratory was destroyed by fire, and have been unable to replace them. I think, however, that there can be no doubt that the same bacterium was isolated from several gum-bearing branches, and that it was actually present in the bark, sufficient precautions being taken to prevent accidental contamination.

A bipolar bacterium in Hashab gum

In concluding this Report, I have to acknowledge my great indebtedness to Dr. Balfour for much assistance and advice in connection with the bacteriological work, which I much regret having lost at such an interesting stage. I am also very much indebted to Dr. Beam for advice and help in the chemical part of my work. He has given me the fullest information obtainable on all points connected with the collection of gum, and also the physical properties, such as hardness and viscosity, which are fully dealt with in his Report.

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